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(54) IMAGE DATA INTERPOLATING DEVICE, IMAGE DATA INTERPOLATING METHOD, AND MEDIUM ON WHICH IMAGE DATA INTERPOLATING PROGRAM IS RECORDED

(57) When a plurality of types of image data are superposed and written onto a color information virtual drawing screen, attribute information of each pixel is written onto an attribute information virtual drawing screen so that the image data can be read out for every type. When results of superposition are read out from a virtual drawing screen for an interpolating process, the results are read out for every type of image data on the basis of the attribute information so that an optimum interpolating process suitable for each type is carried out. Since a margin of each image data is affected by the interpolating process, superposition after the interpolating process is controlled so that the margin is rendered most suitable. As a result, optimum results of interpolation can be achieved even when a plurality of types of image data are co-existent.

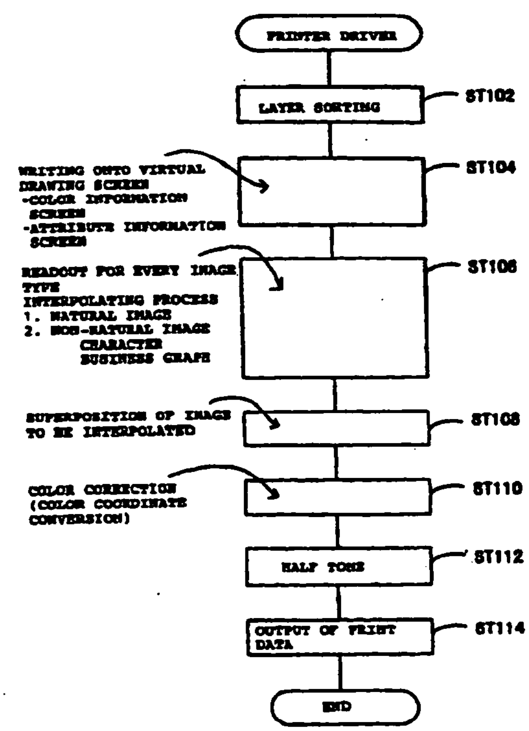

Fig. 4

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Description

[0001] The present invention relates a device and a method for interpolating image data comprising a dot-matrix image and a medium on which a program for interpolating the image data is recorded.

[0002] An image is represented as dot-matrix pixels when treated in a computer etc., and each pixel is represented by a graduation value. For example, a photograph and computer graphics are sometimes displayed on a screen of the computer by 640-dot pixels in the horizontal direction and 480-dot pixels in the vertical direction.

[0003] On the other hand, color printers have recently been improved in their performances rapidly and now have a high accurate dot density, for example, 720 dpi. When an original image composed of 640×480 dots is printed so that a printed image corresponds to the original one in the dots, the printed image becomes smaller than the original one. In this case, images to be printed have various gradation values, and the color printers have different resolutions. Accordingly, the original image data is required to be interpolated between dots before converted to printing image data.

[0004] The prior art has provided, as techniques for interpolating the dots, a nearest neighbor interpolation method (hereinafter, "nearest method") and a cubic convolution interpolation method (hereinafter, "cubic method"). Further, Japanese patent publication No. 6-225140A discloses a technique for providing dot patterns so that an edge takes such an enlarged form as to be smoothed when edge smoothing is performed after dots have been interpolated.

[0005] The aforesaid interpolation techniques have the following problems. The nearest and cubic methods have their respective advantages and disadvantages. On the other hand, there have recently been many cases where a single document to be printed contains a plurality of types of objects to be processed. Accordingly, when an interpolating process is carried out for an object to be processed, the quality of result of interpolation is reduced with respect to a processing mode for which the interpolating process is ill fitted.

[0006] Meanwhile, in the invention disclosed in Japanese patent publication No. 6-225140A, the number of patterns becomes enormously large when a color image is premised on, so that it is difficult to previously prepare the patterns.

[0007] Further, noise pixels are sometimes produced due to an error in the operation when the pixels are generated at a low resolution regarding metacommmand pixels. Such noise pixels are also enlarged by the interpolating process.

[0008] The present has been made in view of the foregoing problem and an object of the invention is to provide a device and method for interpolating image data in which a satisfactory result can be achieved when a plurality of types of objects to be processed is contained, and a medium on which a program for interpolating the image data is recorded.

[0009] To accomplish the object, the invention of claim 1 provides an image data interpolating apparatus which obtains image data containing attribute information capable of distinguishing a type of image for every pixel and enlarges the image data by an interpolating process and which comprises a readout unit which reads out the image data, characterized by an interpolating unit which distinguishes a plurality of image types of the pixels based on the attribute information and applies one of a plurality of interpolating processes differing for every one of the image types to each of the pixels, and a synthesizing unit which synthesizes the pixels interpolated by the different interpolating processes.

[0010] In the invention of claim 1 constructed as described above, the image data is obtained and enlarged by the interpolating process. The image data contains attribute information capable of recognizing a type of image for every pixel. When the readout unit reads out the image data, the interpolating unit distinguishes image types of the pixels based on the attribute information and applies one of a plurality of interpolating processes differing for every one of the image types to each one of the pixels, and the synthesizing unit synthesizes the pixels interpolated by the different interpolating processes.

[0011] More specifically, the images include several types, and a most suitable pixel interpolating process differs according to the types. Accordingly, the image data containing the several types of images is recognized for every type of image and interpolated. The interpolating process and the synthesizing process need not be carried out separately but may be united together.

[0012] The image data is an ordinary one representing a pattern constituted by dot-matrix pixels and should not be limited particularly to a picture as a figure, photograph or characters. Further, the image data itself may be a set of dots but need not represent the respective dots. For example, the image data may be composed of drawing commands for drawing an image or fonts comprising vector information.

[0013] The image data contains several attributes differentiating properties of images and is held so as to be read out with the attributes being recognized. The image data may previously be prepared or may newly be written onto a virtual region on the basis of the image data. As an example suitable for this case, the image data interpolating apparatus of claim 2 is constructed so that in the image data interpolating apparatus of claim 1, a virtual drawing unit is provided which inputs the plurality of types of image data having different image types to superpose the image data in a predetermined order and renders the image types distinguishable, thereby performing a drawing operation in a virtual region, wherein the readout unit reads out the image data from the virtual region.

[0014] That is, the virtual drawing unit superposes the image data in the predetermined order, rendering the types in the image data distinguishable, to thereby perform the drawing operation.

[0015] The types in the image data are recognizable for every pixel. Various techniques to render the types recognizable can be employed. For example, an attribute area may separately be provided so that types of individual data are written as attributes onto the virtual region. Consequently, the type of each pixel can be found when the attribute area is referred to. In this case, writing may be performed by the virtual drawing unit.

[0016] The virtual region may be prepared for every type of image data and have a layer structure with a text screen and a natural screen. The enlarging process may be carried out while the image data is being input from the layer structure by an application. Furthermore, a part of the image data recognizable of the attribute of the image data may be read out for every type, and the remaining part of the image data may be undistinguishable.

[0017] The readout unit reads out the image data of every pixel for every type. For example, when the type can be determined from the attribute area, the readout unit selects the image data to be read out while referring to the attribute area.

[0018] Further, since a two-dimensional processing is performed in the interpolating process, the image data needs to be input accordingly. For this purpose, when the image data is read out from the virtual region, a plurality of lines of the image data may be input for the interpolating process. As a result, a two-dimensional interpolating process can be realized.

[0019] Various types of interpolating process may be employed. For example, the interpolating process by the cubic method is suitable for a natural image though unsuitable for a business graph. On the other hand, the nearest method is suitable for a non-natural image such as the business graph though unsuitable for the natural image. Whether the image data is a natural image or a non-natural image is a kind of characteristic of the image. The interpolating process is selected according to such a characteristic. Further, the interpolating process for the natural image can sometimes be changed depending upon an object. For example, the interpolating process may be changed between a daylight photograph and a night photograph. More specifically, the characteristic of the image may only affect the result of interpolation when the interpolating process is changed.

[0020] As another example, the interpolating unit may be provided with pattern data corresponding to presence or absence of pixel information in a predetermined area and interpolation pixel information with a predetermined interpolating scale factor corresponding to each pattern data. The interpolating unit may input a pixel of the corresponding area from the virtual region and compare the pixel with the pattern data, so that the interpolating process is performed on the basis of the interpolation pixel information corresponding to the matched pattern data.

[0021] In the case of the above-described construction, the interpolating process is carried out by the pattern matching with respect to a predetermined small area. More specifically, the pattern data corresponding to presence or absence of the pixel information corresponding to the small area is prepared, and a pixel in the corresponding area is read out from the virtual region and compared with the pattern data. The interpolating process is performed on the basis of the interpolation pixel information of a predetermined interpolating scale factor corresponding to the pattern data which matches the pattern data. Accordingly, an expected noise pixel can be prepared as the pattern data and the interpolation pixel information in which the noise pixel is deleted according to the pattern data.

[0022] In the aforesaid pattern matching, renewing all the comparison data is troublesome when an object area is moved so that a new pattern matching is performed. In this case, the pattern data may be a rectangular area containing pixels whose number corresponds to a concurrently processible data width, and a new sequence of pixels is incorporated into the comparison data in a moving direction of the rectangular area by a first-in first-out process so that the matching with the pattern data is continued.

[0023] In the above-described arrangement, the pattern matching can be carried out by one operational processing per area in the case of a rectangular area containing pixels whose number corresponds to a concurrently processible data width. Further, when the object area is moved so that a new pattern matching is carried out, not all the comparison data need be renewed, and a new sequence of pixels is incorporated into the comparison data in a moving direction by the first-in first-out process. More specifically, the comparison with pattern data of 16 pixels is performed in the pattern matching of pixels whose number is 4x4. when a square area is moved by one pixel, information about three rows of pixels does not substantially change. Information about presence or absence of one row of four pixels at the forward side relative to the moving direction is incorporated into the comparison data, and information about presence or absence of one row of four pixels at the backward side is out of target. Accordingly, the first-in first-out is carried out with respect to the four pixels, so that not all the comparison data need be renewed. Consequently, the pattern matching can be carried out easily and efficiently.

[0024] The determination cannot be made on the basis of only the presence or absence of pixels when the pattern matching is applied to a color image. Accordingly, pattern data needs to be prepared for every color, but this is unrealistic. On the other hand, the interpolated image data corresponding to the pattern data may be arranged to include color arrangement information of every color in the comparison data.

[0025] In the above-described arrangement, the pixels are matched with the comparison data representative of the presence or absence of pixels. Since the interpolated image information referred to when the pixels have been matched with the comparison data includes the color arrangement information, the interpolation of the color image by the pattern

matching is substantially accomplished by the color arrangement. Consequently, the color image can also be interpolated by the pattern matching.

[0026] The synthesizing unit synthesizes image data for which the pixels thereof have been interpolated. In this case, when interpolating unit is arranged to temporally hold the results of interpolating process for every image data in another region, the image data held in the region is superposed in a predetermined sequence. Alternatively, the results of interpolation may be written onto a predetermined output region with the interpolating process being carried out in the predetermined sequence.

[0027] Although the synthesizing unit thus synthesizes the image data in the predetermined sequence, the superposition can be performed more satisfactorily according to the character of the interpolating process. As an example, the invention claimed in claim 3 is constructed so that in the image interpolating apparatus of claim 1 or 2, the synthesizing unit includes a margin processing unit which adjusts superposition of margins of the image data after interpolation of the pixels.

[0028] In the invention of claim 3 thus constructed, the margin processing unit of the synthesizing unit adjusts the superposition of margins of the image data after the image interpolation.

[0029] Since the interpolating process generates new pixels and there are different techniques in the interpolating process, a configuration of the margin varies when different interpolating processes are applied. For example, when there are an interpolating process resulting in a large variation in the marginal configuration and another interpolating process maintaining an original marginal configuration, the superposition is preferably carried out on the basis of the marginal configuration in the latter. In this sense, the margin processing unit adjusts the superposition.

[0030] The adjustment by the margin processing unit may be changed according to the interpolating process. As an example, the margin processing unit may superpose a plurality of types of image data for which the pixels thereof have been interpolated, in a sequence predetermined according to the interpolating process.

[0031] In the above-described arrangement, the margin is adjusted by superposing the image data in the sequence predetermined according to the interpolating process. In the aforesaid example, there are an interpolating process resulting in a large variation in the marginal configuration and another interpolating process maintaining an original marginal configuration. In this case, the former is first written onto a predetermined output region and thereafter, the latter is overwritten such that the marginal configuration of the latter is used.

[0032] As another example, the margin processing unit may first write onto the output region the image data corresponding to an interpolating process in which the margin is expanded.

[0033] In the above-described arrangement, when there is image data in which the margin is expanded as the result of the interpolating process, the margin processing unit first writes that image data to be interpolated by the interpolating process onto the output region. The margin is narrowed or expanded depending upon the interpolating process. The margin intrudes into an adjacent region when expanded. Accordingly, the image data is first written onto the output region and the marginal portion is overwritten so that a percentage of the portion intruding into the adjacent region is substantially reduced, whereupon the marginal configuration is maintained.

[0034] Furthermore, the margin processing unit may write the image data for which an interpolating process in which the marginal configuration is smoothed is carried out, later than the image data for which another interpolating process is carried out.

[0035] When there are the interpolating process in which the marginal configuration is smoothed and another interpolating process, the interpolating process in which the marginal configuration is smoothed can maintain the marginal configuration. Accordingly, when the image data corresponding to the interpolating process in which the marginal configuration is smoothed is first written onto the output region, the marginal configuration which should not be maintained is maintained, which is inconvenient. Accordingly, the image data corresponding to the interpolating process in which the marginal configuration is smoothed is later written onto the output region.

[0036] Whether the marginal configuration is maintained depends upon a purpose. For example, the margin is easily smoothed in the pattern matching. There is a case where the marginal configuration is maintained when such smoothing is carried out. On the other hand, although shagginess becomes more conspicuous as an interpolating scale factor is increased, as in the nearest method, the marginal configuration can be maintained.

[0037] Furthermore, the invention claimed in claim 4 is constructed so that in the image data interpolating apparatus of claim 3, when the readout unit reads out the image data, the margin processing unit causes the readout unit to read out the image data with a margin enlarged, thereby superposing the image data on the image data interpolated by the interpolating unit on the basis of the image data with the enlarged margin.

[0038] In the invention of claim 4 thus constructed, when the readout unit reads out the image data, the margin processing unit causes the readout unit to read out the image data with a margin enlarged. The image data is then superposed on the image data interpolated by the interpolating unit on the basis of the image data with the enlarged margin.

[0039] The resultant interpolation image data is expanded when the original image data is previously expanded. Then, even when the margin of the resultant interpolation image data adjacent to the expanded image data does not

match that of the expanded image data, that margin is reserved as a foundation and the missing of pixels is prevented.

[0040] Further, the invention claimed in claim 5 is constructed so that in the image data interpolating apparatus of claim 4, the margin processing unit enlarges the margin of the image data with respect to an interpolating process in which information outside the margin is drawn in.

[0041] In the invention of claim 5 thus constructed, when there is an interpolating process in which information outside the margin is drawn in, the margin is enlarged as described above and the interpolating process is then performed. The post-interpolation image data is written onto the output region etc. When the interpolating process draws in information outside the margin, information is diluted since information of a part containing no pixels is drawn in, which influences the margin. On the other hand, when the margin is previously enlarged, the influenced margin is concealed under the margin of the adjacent image data, whereupon the influence is eliminated.

[0042] There are various types of image data, which can mainly be classified into metacommand image data and non-metacommand image data. As an example suitable for such a case, the invention claimed in claim 6 is constructed so that in the image data interpolating apparatus of any one of claims 1 to 5, said plurality of types of image data having different image types include image data corresponding to a metacommand and other image data, which further comprises a non-metacommand pixel interpolating unit which enlarges a marginal region when the pixel corresponding to the image data other than the metacommand and performs an interpolating process so that a predetermined interpolation scale factor is obtained, and a metacommand pixel interpolating unit which generates an interpolated pixel so that the interpolated pixel corresponds to the original metacommand when reading out the pixel corresponding to the metacommand and performing an interpolating process so that the interpolating scale factor is obtained, wherein the synthesizing unit synthesizes a result of interpolation by the non-metacommand pixel interpolating unit and a result of interpolation by the metacommand pixel interpolating unit, the synthesizing unit preferring the result of interpolation by the metacommand pixel interpolating unit with respect to the superposed portion.

[0043] In the invention of claim 6 thus constructed, the non-metacommand pixel interpolating unit reads out from the virtual region etc. the pixels corresponding to the image data other than the metacommand and performs an interpolating process so that a predetermined interpolation scale factor is obtained. In this case, the interpolating process is performed with the marginal region being enlarged. Accordingly, an interpolated image enlarged relative to the original region is obtained. On the other hand, the metacommand pixel interpolating unit also reads out from the virtual region etc. the pixels corresponding to the metacommand and performs an interpolating process so that the predetermined interpolation scale factor is obtained. In the interpolating process, the interpolated pixels are generated so as to correspond to the original metacommand. The synthesizing unit synthesizes a result of interpolation by the non-metacommand pixel interpolating unit and a result of interpolation by the metacommand pixel interpolating unit. The synthesizing unit prefers the result of interpolation by the metacommand pixel interpolating unit with respect to the superposed portion.

[0044] More specifically, the metacommand image is a mass of dot-matrix pixels in the virtual region etc. The metacommand image has a smoothed contour corresponding to the original metacommand in the interpolating process, but the contour is necessarily changed from that before the interpolating process. When the contour is thus changed, a part of the metacommand image may be superposed on the adjacent image other than the metacommand or a gap may be formed. On the other hand, the image other than the metacommand is generated so as to be larger than the original and accordingly, there is less possibility of occurrence of the gap and the image of the metacommand is preferred in the superposed portion. Consequently, a smoothed contour remains.

[0045] The metacommand used here means a vectorial representation of shape. Accordingly, a drawing application would translate the command, drawing a graphic, and the image quality is not deteriorated eve if enlargement or reduction are repeated. On the other hand, information about each pixel is given when the image other than the metacommand is drawn. The information is lost when the image is reduced and cannot be returned even when the image is enlarged. In this sense, the metacommand is used for characters as well as for images.

[0046] The characteristic of the metacommand having such a property cannot always be maintained in the processing by a computer. Accordingly, when the metacommand is represented as a mass of pixels at one time, it needs to be subjected to the same processing as applied to the other image thereafter. However, when whether an image has been drawn by the metacommand, the interpolating technique needs to be changed in the interpolating process in which the image is enlarged. For example, it is considered that an image by the metacommand should generally be interpolated with a margin being smoothed. On the other hand, whether the margin should be smoothed cannot be determined unconditionally regarding the other image. Accordingly, when the metacommand and non-metacommand images are interpolated in the manners different from each other, marginal configurations may differ after the interpolating processes. This is the background of the present invention.

[0047] The virtual drawing unit carries out drawing on the virtual region on the basis of the image data corresponding to the metacommand and the other image data. The virtual drawing unit is capable of recognizing the image data corresponding to the metacommand and the other image data from each other. Various techniques rendering the recognition possible may be employed. For example, an attribute area may separately be provided so that types of the indi-

vidual data in the virtual region are written thereon, or the individual data may be provided with respective attributes. Further, when the number of colors can be reduced, a certain bit can be applied to the attribute.

[0048] The non-metacommand pixel interpolating unit reads out from the virtual region the pixels corresponding to the image data other than the metacommand, carrying out the interpolating process. For example, when the type of the image data can be determined from the attribute area, the non-metacommand pixel interpolating unit reads out the pixels corresponding to the image data other than the metacommand while making reference to the attribute area to select the image data. The non-metacommand pixel interpolating unit further interpolates the pixels by the corresponding interpolating process.

[0049] Various interpolating manners can be employed. For example, the interpolating process by the cubic method is suitable for the natural image, whereas the nearest method is suitable for the non-natural image such as computer graphics.

[0050] The non-metacommand pixel interpolating unit enlarges the peripheral edge region and then carries out the interpolating process. Various processing manners for enlarging the peripheral edge region are employed. As an example, the invention claimed in claim 7 is constructed so that in the image data interpolating apparatus of claim 6, the non-metacommand pixel interpolating unit uses information about the pixel in the marginal region as information about a pixel outside the marginal region.

[0051] In the invention of claim 7 thus constructed, since the peripheral edge region to be enlarged contains no information about pixels, information about pixels in a peripheral region is used as information about pixels in a region to be enlarged. Accordingly, the information may be copied without change or with stepwise changes. Further, copying may be carried out using a working region. Thus, an actually copying work may not be carried out and it is sufficient that the information is substantially usable. The size of the region to be enlarged is not limited particularly. The size of the region depends upon irregularity of the margin resulting from generation of pixels by the metacommand pixel interpolating unit. Even when the metacommand pixel has a concavity, the concavity is allowed to such an extent that the concavity does not result in a gap in the superposition of the image data. For example, when pixel information is read out for every line from the virtual region, a processing for enlarging both ends of the metacommand pixel by one pixel is sufficient.

[0052] The metacommand pixel interpolating unit selectively reads out the pixel corresponding to the metacommand from the virtual region. The metacommand pixel interpolating unit generates an interpolation pixel corresponding to the original metacommand. For example, when the pixel is taken as an image, smoothing a margin or rendering a corner acute corresponds to this processing.

[0053] On the other hand, a metacommand representative of a character contains information about a figure bending in a complicated manner in a small region. Accordingly, an extra dot tends to be generated depending upon an operational accuracy in generation of pixels. As an example suitable for this characteristic, in the interpolating process for the metacommand representative of the character, a noise pixel in the generation of pixels on the basis of the metacommand may be deleted and the pixels may then be interpolated.

[0054] In the above-described construction, determination is made as to whether the pixel is a noise pixel when the pixels are generated on the basis of the metacommand representative of the character. When the pixel is a noise pixel, the noise pixel is deleted and the pixel is then interpolated. Whether the pixel is a noise pixel can generally be determined from a property of the character. For example, one pixel projects in spite of a straight portion. An unnaturally projecting pixel is in a portion where two sides intersect. Or an unnaturally projecting pixel is at an end of a curve. That is, the noise pixel means those which can be produced at a connection in the case where a character is represented by a plurality of vector data.

[0055] On the other hand, a superposing unit synthesizes the result of interpolation by the non-metacommand pixel interpolating unit and the result of interpolation by the metacommand pixel interpolating unit and causes the result of interpolation by the metacommand pixel interpolating unit to take preference over the result of interpolation by the non-metacommand pixel interpolating unit concerning a superposed portion.

[0056] As an example of the processing in which one takes preference over the other, the invention claimed in claim 8 is constructed so that in the image data interpolating apparatus of any one of claims 1 to 7, the synthesizing unit synthesizes the pixels, superposing pixels in the result of interpolation by the metacommand pixel interpolating unit other than background pixels on the result of interpolation by the non-metacommand pixel interpolating unit.

[0057] In the invention of claim 8 thus constructed, the results of interpolating processes held in another area may be superposed in a predetermined sequence if the result of interpolation by the non-metacommand pixel interpolating unit and the result of interpolation by the metacommand pixel interpolating unit are preliminarily held in the another area. Alternatively, the results of interpolation may be superposed while the interpolating processes are carried out in a predetermined sequence.

[0058] The aforesaid image data interpolating technique should not be limited to the substantial apparatus. It can easily be understood that the technique is functioned as a method.

[0059] The aforesaid image data interpolating apparatus may exist independently or may be incorporated in equip-

ment. Thus, the scope of the invention covers various forms of implementation. Accordingly, the invention may be implemented as software or hardware.

[0060] When the invention is implemented as software for an image data interpolating apparatus, the invention applies equally to a medium on which the software is recorded.

[0061] When the invention is implemented as software, hardware and operating system can be employed or the invention may be implemented independent of them. For example, a process for inputting image data for the interpolation can be accomplished by calling a predetermined function in an operating system or by inputting from hardware without calling the function. Even when the invention is actually implemented under interposition of hardware, it can be understood that the invention can be implemented only by a program in a stage of recording the program on a medium and circulating the medium.

[0062] The recording medium may be a magnetic recording medium or a photomagnetic recording medium, or any recording medium that will be developed in the future. Further, the invention may take such a replicated form as a primary replicated product, secondary replicated product, etc. In addition, the invention may be supplied through use of a communication line.

[0063] Still more, there may be provided such as arrangement that some parts of the present invention are embodied in software while the other parts thereof are embodied in hardware. In a modified embodiment of the invention, some parts thereof may be formed as software recorded on a storage medium to be read into hardware as required.

[0064] The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram showing an image data interpolating apparatus of one embodiment in accordance with the present invention;
Fig. 2 is a block diagram showing a concrete example of hardware for the image data interpolating apparatus;
Fig. 3 is a schematic block diagram showing another example of application of the image data interpolating apparatus;
Fig. 4 is a flowchart of main processing of the image data interpolating apparatus of the invention;
Fig. 5 shows writing onto a virtual drawing screen;
Figs. 6A and 86B show comparison of color information and attribute information on the virtual drawing screen;
Fig. 7 shows the concept of the cubic method;
Fig. 8 shows the concept of the nearest method;
Fig. 9 shows a case where data of each lattice point is moved in the nearest method;
Fig. 10 is a schematic view showing the condition before interpolation by the nearest method;
Fig. 11 is a schematic view showing the condition after interpolation by the nearest method;
Fig. 12 shows the concept of the bilinear method;
Fig. 13 is a graph showing variations in the interpolation function;
Fig. 14 shows a character image written on the color information virtual drawing screen;
Fig. 15 shows a case where interpolation information is obtained by pattern matching;
Fig. 16 shows a case where interpolation information is obtained by pattern matching in differing scale factors;
Fig. 17 shows a case where interpolation information including color allocation information is obtained by pattern matching;
Figs. 18A to 18C show a concrete data processing technique for pattern matching;
Fig. 19 is a flowchart showing the interpolation process for a natural image in the image data interpolating apparatus of the invention;
Fig. 20 is a flowchart showing the interpolation process for a non-natural image in the image data interpolating apparatus of the invention;
Figs. 21A and 21B show a case where image data is read out for every type;
Figs. 22A and 22B show a case where image data is read out into a buffer for every type;
Figs. 23A to 23E show an inadequacy in a case where mixed image data are separated for the interpolation process;
Figs. 24A to 24D show a countermeasure against the inadequacy and its effect;
Fig. 25 shows an effect which smoothens the margin;
Fig. 26 is a block diagram showing the image data interpolating apparatus of another embodiment in accordance with the invention;
Fig. 27 is a flowchart of main processing of the image data interpolating apparatus of the invention;
Fig. 28 shows writing onto a virtual drawing screen;
Figs. 29A to 29D show a process of eliminating noise dot in a character by pattern matching;
Fig. 30 is a flowchart showing the interpolation process for non-metacommand pixels in the image data interpolating apparatus of the invention;

Fig. 31 is flowchart showing the interpolation process for metacommand pixels in the image data interpolating apparatus of the invention;

Figs. 32A to 32C show a case where image data is read out for every type and a margin extending process;

Figs. 33A and 33B show a case where image data is read out into a buffer for every type; and

Figs. 34A to 34D show the condition where the margin is extended by the margin extending process.

[0065] One embodiment of the present invention will be described with reference to the drawings.

[0066] Fig. 1 is a block diagram showing an image data interpolating apparatus of one embodiment in accordance with the present invention, and Fig. 2 is a block diagram showing hardware to which the invention is applied.

[0067] In data processing in computers etc., an image is represented by dot-matrix pixels, and image data is composed of number of data each indicative of a pixel. An image should not be limited to a natural image such as photograph. A character can be an image in the sense that the character is a collection of pixels. Computer graphics and business graph can be images. These are commonly image data but delicately differ from each other in the properties, and accordingly, the matching with an interpolating process differs from one another according to the properties.

[0068] In view of the differences of image properties, a virtual drawing unit C11 reads a plurality of types of image data having different image properties, renders the types distinguishable, superposes the image data in a predetermined sequence, and draws on a virtual region etc. On the other hand, a readout unit C12 and an interpolating unit C13 read out the image data of every pixel for every attribute from the distinguishable virtual region and interpolate the pixels by an interpolating process according to the property of the image. A superposing unit C14 as an example of synthesizing unit writes image data interpolated according to the property of the interpolating process onto a predetermined output area in a superposed state.

[0069] The embodiment employs a computer system 10 as an example of hardware realizing the image data interpolating apparatus.

[0070] Fig. 2 is a block diagram showing the computer system 2. The computer system 10 includes as an image input device a scanner 11a, a digital still camera 11b and a video camera 11c all of which are connected to a computer 12. Each input device generates image data representing an image as dot-matrix pixels and is capable of outputting the image data to the computer 12. The image data is represented in three primary colors of RGB in 256 gradations so that about 16 million and 700 thousand colors can be represented.

[0071] A floppy disk drive 13a, a hard disk 13b and a CD-ROM drive 13c each serving as an external auxiliary storage are connected to the computer 12. Main programs relating to the system are recorded on the hard disk 13b. Other required programs are read from a floppy disk or CD-ROM as the occasion may demand.

[0072] Further, a modem 14a serving as a communication device which connects the computer 12 to an external network etc. is connected to the computer 12. The modem 14a is further connected to the external network via a public communication line through which software and data can be downloaded. Although an operator externally accesses via the modem 14a and the public communication line in the embodiment, a LAN adapter may be provided for the operator to access the network, instead. Additionally, a keyboard 15a and a mouse 15b are provided for operation of the computer 12.

[0073] The computer system 10 further includes a display 17a and a color printer 17b each serving as an image output device. The display 17a has a display area of 800×600 pixels in the horizontal and vertical directions respectively, so that about 16 million and 700 thousand colors can be displayed for every picture element as described above. However, this is only one example of resolution. The resolution of the display 17a may be variable, for example, it may be 640×480 pixels or 1024×720 pixels.

[0074] On the other hand, the color printer 17b, which is an ink-jet printer, is capable of printing an image with dots on printing paper serving as a recording medium using four color inks of CMYK. The color printer 17b has an image density of 360×360 dpi or 720×720 dpi and can thus perform a high-density printing. The color printer 17b has two gradations as to whether color ink is applied or not.

[0075] Predetermined programs are executed in the computer 12 so that the image data input by the image data input device is displayed or otherwise output by the image output device. Of these programs, an operating system (OS) 12a as a basic program runs on the computer 12. A display driver (DSP DRV) 12b and a printer driver (PRT DRV) 12c are incorporated in the operating system 12a. The display driver 12b instructs the display 17a to perform a displaying function, whereas the printer driver 12c instructs the color printer 17b to perform a printing function. These drivers 12b and 12c depend on the types of the display 17a and color printer 17b respectively and can accordingly be added or changed according to the respective types. Further, additional functions other than standard processes may be accomplished depending on the respective types of the display 17a and color printer 17b. In other words, various additional processes can be accomplished within allowable ranges while a common processing system is maintained on the standard system of the operating system 12a.

[0076] An application 12d is executed on the operating system 12a serving as the basic program. The application 12d has various processing contents. For example, it monitors operations of a keyboard 15a and a mouse 15b each

serving as an operating device. When each device is operated, the application 12d controls the external equipment so that the corresponding computation processing is carried out. The application 12d further displays the results of processing on the display 17a or output them to the color printer 17b.

[0077] In the above-described computer system 10, a scanner 11 serving as an image input device reads a photograph etc. to obtain image data. Further, the application 12d for a word processor etc. can stick read photograph image or business graph based on the results of tabular computation as well as document. Such a consolidated document can be output to the display 17a or color printer 17b each serving as an image output device to be displayed. The consolidated documents differ in the character, photograph or business graph but are common in a point that an image is constituted by a collection of pixels.

[0078] When the consolidated document is output to be displayed, pixels displayed on the display 17a as they are cannot correspond to pixels on the color printer 17b. A pixel density in the case where the pixels are generated on the application 12d and displayed on the display 17a is not equal to one of the color printer 17b. Of course, there may be a case where the pixel density of the display 17a equals that of the color printer 17b. However, in many cases, the pixel density of the color printer 17b having an improved pixel density for high image quality is higher than that of the ordinary display 17a.

[0079] In view of the aforesaid problem, the operating system 12a determines a reference pixel density and executes a resolution conversion so that the difference between the reference density and the pixel density of an actual device is resolved. For example, when the display 17a has a resolution of 720 dpi and the operation system 12a has a reference resolution of 360 dpi, the display driver 12b executes the resolution conversion between them. Further, when the color printer 17b has a resolution of 720 dpi under the same condition, the printer driver 12c executes the resolution conversion between them.

[0080] The resolution conversion is a process for increasing the number of constituent pixels of the image data and accordingly corresponds to an interpolating process. Each of the display driver 12b and printer driver 12c has a function of executing the interpolating process.

[0081] In the embodiment, the display driver 12b or the printer driver 12c writes image data on a virtual screen for every type of the image data so that the image data is distinguishable and further reads out the image data for every type from the virtual screen, executes the interpolating process in a suitable interpolating technique, superposes the interpolated image data to output a final image to the display 17a or the color printer 17b, as will be described later. In this sense, the display driver 12b and the printer driver 12c constitute the above-described virtual drawing unit C11, the readout unit C12, the interpolating unit C13 and the superposing unit C14. The display driver 12b and the printer driver 12c are stored on the hard disk 13b and input to the computer 12 upon start of the computer system 10 to run. When put to work, these drivers recorded on a medium such as a CD-ROM or a floppy disk are installed on the hard disk. Accordingly, such a CD-ROM or floppy disk constitutes a medium on which an image data interpolating program is recorded.

[0082] Although the image data interpolating apparatus is realized as the computer system 10 in the embodiment, the computer system is not necessarily required. A system in which the same interpolating process is required for a plurality of image data having differing properties of images may be provided, instead. For example, Fig. 3 shows a network computer 19a, which is connected via a public telephone line to an external wide-area network. In such a wide-area network, image data having different image properties including character information, photographic images, etc. are transmitted and received. The network computer 19a obtains such image data and displays the image data on a television monitor 19b or output the image data to a printer (not shown). In this case, too, the change of the image resolution is required, or when the operator wishes to enlarge a part of the image, the image is interpolated with an operation such as zooming and then displayed.

[0083] The interpolating process may be carried out at the side of a display output device but not at the computer side. In the example of a color printer, script type print data is input and the interpolating process is carried out in execution of matching with a printing resolution of the color printer.

[0084] Fig. 4 is a flowchart of the resolution conversion carried out by the printer driver 12c.

[0085] At step ST102, image data is input and sorted for superposition. More specifically, an image read from the scanner 11a on the application 12d, a character input on the keyboard 15a, and a business graph generated on tabular calculation software are stuck as a single consolidated document. Superposition is required in this case. Particularly in a field of DTP, an image and a character are directly superposed in most cases such that one picture is generated. A complicated superposition is required in this case. Although an image of a superposed lower layer is invisible, the image exists on the data and accordingly, the data is again superposed by the printer driver 12c. The concept of the layer is utilized when the images are superposed. A command of the image data is sorted so that the image data are arranged into upper and lower layers. The image data for the lower layer is written.

[0086] At step ST104, data is written onto a virtual drawing screen serving as a virtual region on the basis of the image data rearranged as described above. Fig. 5 typically shows writing onto the virtual drawing screen. When the commands of the image data are sorted on the basis of the arrangement of layers, drawing functions according to the

respective sorted commands are called and data is written for every pixel onto a color information virtual drawing screen and an attribute information virtual drawing screen each which is allocated to a memory. Three bytes corresponding to respective color components of red, green and blue for every pixel are allocated to the color information virtual drawing screen. An allocated memory area equals the number of pixels in the horizontal direction multiplied by the number of pixels in the vertical direction. The attribute intonation virtual drawing screen is provided for determining what each pixel is, a natural image (N), a character (C) or a business graph (B). One byte is allocated for each pixel, and an identification code (N, C or B) of the attribute is written onto the attribute information virtual drawing screen. Bit map image data is treated as a natural image. However, since the bit map image data is not always a natural image in the strict sense, the image data may be analyzed so that whether the image data is a natural image is determined.

[0087] Figs. 6A and 6B show a correspondence between the color information virtual drawing screen and the attribute information virtual drawing screen. When one line in the horizontal direction at a reference resolution is supposed, the color and the type of each pixel is written. Accordingly, a pixel of a natural image, a character or a business graph can be selected from the written attribute information.

[0088] Although the attribute information and the color intonation are separately written onto the virtual drawing screen in this example, a writing manner should not be limited to this. For example, four bytes may be allocated to each pixel, that is, one byte for the attribute intonation may be added to the color information. Further, a screen onto which superposition information is written may be separated from a screen onto which color information is written for every type, and the superposition may be carried out while the superposition information is referred to.

[0089] At step ST106, image data is read out for every image type from a virtual drawing screen as shown in Fig. 5, and an optimum interpolating process according to the image type is carried out. Techniques for the interpolating process prepared in the embodiment will be described.

[0090] As an interpolating process suitable for a natural image such as photograph, the interpolating process by a cubic method is executable. The cubic method utilizes data of sixteen lattice points, that is, four lattice points surrounding a point Puv to be interpolated and lattice points outside the four lattice points, as shown in Fig. 7. An equation using a cubic convolution function is expressed as follows:

$$P=[f(y1)f(y2)f(y3)f(y4)]\begin{pmatrix} P11 & P21 & P31 & P41 \\ P12 & P22 & P32 & P42 \\ P13 & P23 & P33 & P43 \\ P14 & P24 & P34 & P44 \end{pmatrix}\begin{pmatrix} f(x1) \\ f(x2) \\ f(x3) \\ f(x4) \end{pmatrix}$$

[0091] The degree of influence according to the distance is expressed by a cubic convolution function as:

$$f(t)=\{\sin(\pi t)\}/\pi t.$$

Each of the distances x1 to x4 and y1 to y4 is obtained using an absolute coordinate value (u, v) of the lattice point Puv as:

$$x1=1+(u-|u|) \qquad y1=1+(v-|v|)$$

$$x2=(u-|u|) \qquad y2=(v-|v|)$$

$$x3=1-(u-|u|) \qquad y3=1-(v-|v|)$$

On the above assumption, the aforesaid equation is expanded as follows:

$$P=[f(y1)\,f(y2)\,f(y3)\,f(y4)]\begin{bmatrix} P11\cdot f(x1)+P21\cdot f(x2)+P31\cdot f(x3)+P41(x4) \\ P12\cdot f(x1)+P22\cdot f(x2)+P32\cdot f(x3)+P42(x4) \\ P13\cdot f(x1)+P23\cdot f(x2)+P33\cdot f(x3)+P43(x4) \\ P14\cdot f(x1)+P24\cdot f(x2)+P34\cdot f(x3)+P44(x4) \end{bmatrix}$$

$$\begin{aligned} &=f(y1)\{P11\cdot f(x1)+P21\cdot f(x2)+P31\cdot f(x3)+P41(x4)\} \\ &+f(y2)\{P12\cdot f(x1)+P22\cdot f(x2)+P32\cdot f(x3)+P42(x4)\} \\ &+f(y3)\{P13\cdot f(x1)+P23\cdot f(x2)+P33\cdot f(x3)+P43(x4)\} \\ &+f(y4)\{P14\cdot f(x1)+P24\cdot f(x2)+P34\cdot f(x3)+P44(x4)\} \end{aligned}$$

$$\begin{aligned} &=P11\cdot f(x1)\cdot f(y1)+P21\cdot f(x2)\cdot f(y1)+P31\cdot f(x3)\cdot f(y1)+P41(x4)\cdot f(y1) \\ &+P12\cdot f(x1)\cdot f(y2)+P22\cdot f(x2)\cdot f(y2)+P32\cdot f(x3)\cdot f(y2)+P42(x4)\cdot f(y2) \\ &+P13\cdot f(x1)\cdot f(y3)+P23\cdot f(x2)\cdot f(y3)+P33\cdot f(x3)\cdot f(y3)+P43(x4)\cdot f(y3) \\ &+P14\cdot f(x1)\cdot f(y4)+P24\cdot f(x2)\cdot f(y4)+P34\cdot f(x3)\cdot f(y4)+P44(x4)\cdot f(y4) \end{aligned}$$

The degree of influence f(t) according to the distance is approximated by the following cubic equation:

$$f(t)=\{\sin(\pi t)\}/\pi t$$

$$\fallingdotseq\begin{cases} 1-2|t|**2+|t|**3 & :0\le|t|<1 \\ 4-8|t|+5|t|**2-|t|**3 & :1\le|t|<2 \\ 0 & :2\le|t \end{cases}$$

[0092] In the cubic method, the degree of influence varies gradually gradually as it approaches from one lattice point to the other lattice point. The cubic method has a characteristic that this variation of the influence becomes cubic.

[0093] As an interpolating process suitable for a non-natural image such as computer graphics or business graph, the interpolating process by a nearest method is executable. In the nearest method, as shown in Fig. 8, distances between an interpolation point Puv and four peripheral lattice points Pij, Pi+1j, Pij+1 and Pi+1j+1 respectively are obtained. Data of the nearest lattice point is displaced to the interpolation point Puv. This is expressed by the following equation:

$$Puv=Pij$$

where i=[u+0.5] and j=[v+0.5], and each bracket indicates that an integral part is taken in the Gauss' notation.

[0094] Fig. 9 shows a case where the number of pixels is trebled both in the length and the width by the nearest

method. The data of the nearest one of pixels at four corners is displaced as a pixel to be interpolated. Fig. 10 shows the original image and Fig. 11 shows an image obtained by interpolating the pixels in the above-described method. The relation between obliquely arranged black pixels and white pixels serving as the background in the original image is maintained in the interpolated image of Fig. 11 in which the black pixels are trebled in the number thereof and arranged obliquely.

[0095] In the nearest method, edges of the original image are maintained in the interpolated image without change. Accordingly, when the interpolated image is scaled up, jags are conspicuous although the edges are maintained. In other methods, on the other hand, the pixel to be interpolated is processed so as to be changed smoothly by using data of pixels around it. As a result, although jags are less conspicuous, part of the intonation of the original data is cut off such that the image is rendered edgeless. Accordingly, these other methods are unsuitable for the computer graphics or business graph.

[0096] Although the above-described nearest method and cubic method are used in the embodiment, a bilinear interpolation method will be described as another interpolation method in order that the characteristics of these methods may be understood.

[0097] The bilinear method is similar to the cubic method in that the influence degree varies gradually as it approaches from one lattice point to the other lattice point, as shown in Fig. 12. However, the bilinear method differs from the cubic method in that the variation is linear and depends upon only data of the lattice points at the opposite sides. More specifically, a region defined by the four lattice points Pij, Pi+1j, Pij+1 and Pi+1j+1 surrounding the interpolation point Puv is divided by the interpolation point into four subdivisions. Diagonally located data is weighted on the basis of area ratios among the subdivisions. This is expressed as the following equation:

$$P=\{(i+1)-u\}\{(j+1)-v\}Pij+\{(i+1)-u\}\{v-j\}Pij+1+\{u-i\}\{(j+1)-v\}Pi+1j+\{u-i\}\{v-j\}Pi+1j+1$$

where $i=[u]$ and $j=[v]$.

[0098] In each of the cubic method and the bilinear method, the influence degree varies gradually as it approaches from one lattice point to the other lattice point. However, the variation is cubic in the cubic method, whereas the variation is linear in the bilinear method. This difference is large. Fig. 13 shows the two-dimensional results of interpolations by the nearest, cubic and bilinear methods. The axis of abscissas denotes a location and the axis of ordinates denotes an interpolation function corresponding to the above-described influence degree according to the distance between the interpolation point and each lattice point. The lattice points exist at locations where t=0, t=1 and t=2, respectively. The interpolation points are at locations where t=0 and 1.

[0099] In the bilinear method, the interpolation function varies linearly between adjacent points (t=0 and 1). As a result, since marginal portions are smoothed, a resultant image is blurred on the screen. More specifically, when the marginal portions differ from corner portions and are smoothed, an original contour of the image is lost in the case of computer graphics and the image becomes out of focus in the case of photograph.

[0100] On the other hand, in the cubic method, the interpolation function gradually approximates the lattice point between the adjacent points (t=0 and 1), generating an upward convexity. Further, the interpolation function becomes downwardly concave between adjacent points (t=1 and 2). In other words, one edge portion is varied so as to have such a difference as not to produce a step. As a result, the sharpness is increased and no step is produced in the photograph. However, since an edge does not have any analogue change in the computer graphics, the cubic method is unsuitable therefor.

[0101] An interpolating process of pattern matching will now be described.

[0102] Fig. 14 shows a character image written on the color information virtual drawing screen. The character is also composed of dot-matrix pixels arranged in the horizontal and vertical directions, and each dotted portion (●) is an image pixel, whereas each blank portion (○) is a background pixel.

[0103] In the pattern matching, one area comprising sixteen pixels serving as a square area of 4×4 pixels as shown in Fig. 15 is matched with a previously prepared pattern data, so that interpolating pixels are generated with respect to a square area comprising inner four pixels (2×2 pixels). Outside pixels are also referred to in spite of the square area of four pixels. The reason for this is that the result of interpolation for the square area of four pixels changes depending on whether peripheral pixels exist. Fig. 15 shows two pattern data, that is, the area matches the pattern data when the area comprises four pixels, whereas the area differs from the pattern when the area comprises sixteen pixels. In pattern data A, dots are arranged vertically with one dot projecting sideways. In pattern data B, three of four dots are dotted. In pattern data A, it is preferable that dots are arranged into an angled shape so that an image of projection is represented. When three pixels are added, they are preferably added so as to represent a triangle. Accordingly, an interpolation pixel pattern differs according to the pattern data.

[0104] A plurality of sets of interpolation pixel patterns are prepared for every scale factor. Fig. 16 shows an example in which the scale factor is 1.5 in the vertical and horizontal directions.

[0105] When the pattern matching is applied to color data, a large number of pattern data should be prepared even

in the example of four pixels. More specifically, the pattern matching results in combinations the number of which corresponds to permutations of the number of colors each pixel can take. In the embodiment, however, pattern comparison is carried out on the basis of presence or absence of dot and the color data is coped with by color allocation, whereupon the above-described problem is solved. Fig. 17 shows an example of such a case. The color data is compared with the pattern data comprising sixteen pixels as in the above-described example. Concerning four pixels, a color of each pixel is correlated with the interpolation pixels. Consequently, no previous processing for determining the colors of the interpolation pixels is required, and the number of pattern data is reduced, so that an amount of processing and an amount of resource are considerably reduced.

[0106] Figs. 18A to 18C show a more concrete technique for pattern matching on the basis of sixteen pixels. Fig. 16A shows an arrangement of original pixels to be interpolated. The pattern matching is executed with a small area of sixteen pixels is displaced. The pattern matching is carried out while a small area of the sixteen pixels is displaced. In this case, not all the information about the sixteen pixels need be renewed every time the small area is moved. In Fig. 18A, object pixels are represented as "E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, and T." Fig. 18B shows a data register area of the CPU etc. for processing the small area. Whether each pixel is dotted is represented by one-bit of "1" or "0," so that the pattern matching can be carried out when data width of sixteen bits is provided. When the small area is moved by one pixel, four pixels of "A, B, C and D" are newly added to the small area, whereas four pixels of "Q, R, S and T" are excluded from the small area, as shown in Fig. 18C. Thus, the data register area is shifted by four bits and four bits corresponding to the four pixels of A, B, C and D" are introduced at LSB side.

[0107] Further, when sixteen bits are utilized as an address concerning the arrangement of pattern data, the matching process includes only an addressing process, whereupon the interpolation pixel information can be obtained.

[0108] On the premise that the aforesaid interpolating process is executable, the image data is divided into a type belonging to a natural image and a type belonging to a non-natural image. The processing as shown in Fig. 19 is carried out for the former, whereas the processing as shown in Fig. 20 is carried out for the latter. Figs. 21A and 21B show a case where image data is read out by one line for every type of image. The pixels are sorted out for every type of a natural image, character and business graph while it is determined whether each pixel on the color information virtual drawing screen is a natural image, character or business graph on the basis of attribute information virtual drawing screen. Pixel information previously initialized as background pixels is applied when sorted.

[0109] Only the arrangement of pixels in the horizontal direction is insufficient for execution of the interpolating process, and information of pixels in the vertical direction is also required. Accordingly, four lines of pixels are actually read out to be stored in a work area, so that the interpolating process is carried out. Employment of four lines in the embodiment is based on the fact that sixteen pixels (4×4 pixels) are treated as a processing unit in the cubic method and the pattern matching. The number of lines may be increased or reduced as the need arises.

[0110] A margin extending process is carried out for the natural image at step ST202. A margin is previously extended at the peripheral edge of a pixel in the margin extending process. Fig. 23 shows the necessity of the process.

[0111] First, a region of natural image and a region of non-natural image are mixed so as to be adjacent to each other as shown in Fig. 23A. However, when the image data is divided for every type, a blank region is produced as shown in Fig. 23B. At this time, the blank is processed merely as a background color.

[0112] On the other hand, the cubic method utilizes the cubic function so that the interpolation pixel is smoothly changed. Accordingly, information about pixels outside a region to be interpolated is used in that region. Concerning the square region of sixteen pixels, when pixels are interpolated in the inside square region of four pixels, information about outside twelve pixels is utilized. In short, outside information is brought in at the time of interpolation.

[0113] This results in no problem inside a natural image. However, the background pixels are generated in a marginal portion adjacent to the background pixels. Accordingly, information about nothing or information about white or black is utilized in the interpolating computation. Fig. 23C shows that information about background pixel generated in the margin of the region of natural image is brought into the adjacent pixel, so that the interpolating computation influenced by the brought information is carried out for the marginal pixels of interpolated ones. Since the aforesaid other method does not bring in the outside information, the influence upon the margin need not be considered as shown in Figs. 23D and 23E.

[0114] Figs. 24A to 24D show a countermeasure in the case where the outside information is brought in. In Fig. 24A, three (A to C) of nine pixels contain pixel information and the other six pixels constitute background pixels. One Pixel adjacent to the margin is copied outside the margin such that the margin is extended, as shown in Fig. 24B. Information about outside background pixels is not brought in when interpolation pixels are generated in original regions after the marginal extension (Fig. 24C). This example supposes the case of the cubic method, and the margin is extended outward by one pixel. However, the margin may be extended by the number of pixels necessary in the interpolating process.

[0115] The process for extending the margin has two sides. One side is directed to not bringing in the information about background pixels adjacent to the margin in the interpolating process bringing in the pixel information from the outside region. The other side is directed to expanding the margin. Fig. 24D shows an example in which after extension

of the margin, the interpolating process is carried out for the pixels including extended ones. When the margin is extended, the pixels are generated in a portion which should originally be left as background pixels. This results in invasion into an adjacent image region such that an area ratio between adjacent image regions changes. However, the problem of the area ratio can be solved by overwriting the result of interpolating process carried out for the other image region.

[0116] A true purpose for extending the margin is to make a foundation. Referring to Figs. 23A to 23E, for example, the natural image and the non-natural image are adjacent to each other when they are co-existent and accordingly, no gaps are produced. However, the interpolating process may change a marginal contour. This change may result from a problem in the computation or an influence of the pattern matching. Since the image data is smoothed according to an interpolating scale factor particularly in the pattern matching as shown in Fig. 25, matching of an image region before interpolation with an adjacent image region is not taken into consideration. Accordingly, there is a case where the margin of an interpolation pixel prepared by the pattern matching does not correspond with the margin of an interpolation pixel obtained by another interpolating process. In this case, a background pixel resulting in a gap is generated. When a background pixel is generated where no background pixel is existent, only that pixel becomes white. In such a case, the region of one image is previously enlarged. Even in a case where a background pixel is generated in the margin when the interpolating process has been carried out for the other image, the background pixel is prevented from appearing as a gap since pixels of the adjacent image region are generated in the foundation.

[0117] The margin extending process is carried out in the former sense at step ST202, and the interpolating process by the cubic method is carried out at step ST204. Thus, the pixels of the natural image are distinguished and read out and the interpolating process suitable for the natural image can be carried out.

[0118] On the other hand, the non-natural image is divided into a character image and a business graph at step ST302. The interpolating process by the pattern matching is carried out for the character image at step ST306, and the interpolating process by the nearest method is carried out for the business graph at step ST304. The pattern matching is carried out for the character image so that an attractive margin contour is obtained. Regarding the business graph and computer graphics, since an original margin contour is preserved, a suitable interpolating process can be carried out. In the business graph and computer graphics, there is a case where maintaining the original margin contour is preferable, whereas there is another case where a smoothed margin is preferred. Accordingly, the correspondence between the image data type and the interpolating process may be selectable.

[0119] The natural image is firstly written at step ST206 after completion of the interpolating process, and the non-natural image is secondly written at step ST308 after completion of the interpolating process. The steps ST206 and ST308 are shown by chain line in the flowcharts of Figs. 19 and 20 respectively. These processes actually correspond to an interpolated image superposing process at step ST108 in the flowchart of Fig. 4.

[0120] The pixels of the natural image and the pixels of the non-natural image are divided and interpolated in the discrete work areas. When the natural and non-natural images are combined, the natural image is firstly written and the non-natural image is secondly written. In this case, the firstly written pixels remain when the firstly and secondly written pixels are not superposed. The secondly written pixels remain when the firstly and secondly written pixels are superposed.

[0121] The above-described writing order is one mode of the superposing process. In this example, the interpolating process by the pattern matching is carried out for the secondly written pixels. The pattern matching puts emphasis on smoothing the margin as shown in Fig. 25. Accordingly, a benefit of the pattern matching can effectively be obtained even when the marginal contour is not smoothed in the firstly written pixels. Further, the margin extending process is carried out in the firstly written pixels so that the margin is extended. The interpolating process is carried out for the secondly written pixels without marginal extension. In this case, when the superposition of the pixels is carried out, the foundation can effectively be prevented from being exposed. Thus, when the superposition at the marginal portion is considered according to the nature of the interpolating process, the foundation can be prevented from being exposed or the marginal contour can be rendered fine. These processes constitute a margin processing unit and a superposing unit (synthesizing unit) respectively.

[0122] A control manner for the above-described writing order is varied on an actual program. Accordingly, only the writing order needs to be maintained in any way and steps ST206 and ST308 are shown by chain line in this sense.

[0123] When the interpolated pixels are superposed, a color correction is carried out for conversion of color coordinates from RGB to CMYK at step ST110. A half tone process is carried out at step ST112 since the color printer 17b has two gradations. Print data is output to the color printer 17b at step ST114.

[0124] The foregoing description relates to the printer driver 12c and can also be applied to the display driver 12b. When a plurality of types of image data are superposed and

[0125] written onto the color information virtual drawing screen, attribute information of each pixel is written on the attribute information virtual drawing screen so that the image data are distinguished for every type and read out. When the result of superposition is read out from the virtual drawing screen and the interpolating process is carried out, the image data is read out for every type thereof on the basis of the attribute information, so that the interpolating process

suitable for each type is carried out. Further, since the margin of the image data is affected by the interpolating process, the superposition carried out after the interpolating process is controlled so that a most suitable margin is obtained. Consequently, an optimum result of interpolation can be achieved even when the image data are co-existent.

[0126] In the foregoing embodiment, the types of image data include the natural image and non-natural image. However, the image data may include metacommand and non-metacommand and processing for them can be accomplished.

[0127] Fig. 26 is a block diagram showing the image data interpolating apparatus of another embodiment in accordance with the invention.

[0128] In this embodiment, in view of the difference in the natures of the images, the virtual drawing unit C21 inputs image data corresponding to metacommand and another image data and superposes the image data in a predetermined order so that both image data are distinguishable from each other, drawing on the virtual region. The readout unit C22 reads out the image data and a non-metacommand pixel interpolating unit C23 carries out an interpolating process so that the pixel corresponding to the image data other than the metacommand in the virtual region takes a predetermined interpolating scale factor. At this time, the peripheral region is extended and the interpolating process is carried out. Accordingly, an interpolated image having a larger region than the original is obtained. On the other hand, a metacommand pixel interpolating unit C24 also carries out an interpolating process so that the pixel corresponding to the image data other than the metacommand in the virtual region takes a predetermined interpolating scale factor. However, the metacommand pixel interpolating unit C24 generates an interpolated pixel corresponding to the original metacommand. A superposing unit C25 synthesizes the result of interpolation by the non-metacommand interpolating unit C23 and the result of interpolation by the metacommand interpolating unit C24. Regarding an overlapped portion, the result of interpolation by the metacommand pixel interpolating unit C24 has priority to the result of interpolation by the non-metacommand pixel interpolating unit C23.

[0129] In the embodiment, the display driver 12b and the printer driver 12c constitute the virtual drawing unit C21, readout unit C22, non-metacommand pixel interpolating unit C23, metacommand pixel interpolating unit C24 and superposing unit C25.

[0130] Fig. 27 is a flowchart showing the resolution conversion carried out by the printer driver 12c. The image data is input and sorted according to the superposition at step ST402. The rearranged image data is written onto the virtual drawing screen serving as the virtual region at step ST404. Fig. 28 typically shows writing onto the virtual drawing screen. The attribute information virtual drawing screen is used so that each pixel is determined to be a non-metacommand pixel (N), or a character (C) or a business graph (B) of the metacommand pixel. One byte is allocated for every pixel so that an attribute identification code (N, C or B) is written. More specifically, bit-map image data is processed as the non-metacommand pixel. The bit-map image data includes computer graphics as well as photograph. The bit-map image data may be divided into them and the interpolating process may be changed according to them, or a predetermined interpolating process may be applied uniformly. Whether the image data is the photograph or computer graphics can be determined by analyzing the image data. As one example, the image data may be determined to be a natural image when the number of used colors is large, whereas the image data may be determined to be a non-natural image when the number of used colors is small. In the case of a natural image, even when objects have the same color, they are determined to have a plurality of colors due to shading. The relationship between the color information virtual drawing screen and the attribute information virtual drawing screen is the same as shown in Figs. 6A and 6B.

[0131] At step ST406, the image data is read out from the virtual drawing screen as shown in Fig. 28 for every type of image and an optimum interpolating process according to the image type is carried out.

[0132] As an interpolating process suitable for a natural image such as photograph, which is an example of non-metacommand pixel, the interpolating process by a cubic method is executed. As an interpolating process suitable for a non-natural image such as computer graphics, which is another example of the non-metacommand pixels, the interpolating process by a nearest method is executed. On the other hand, the interpolating process by the pattern matching is carried out for the metacommand pixel.

[0133] Pixels to be written are specified regarding the non-metacommand image when the drawing function according to the image data is called and data is written on the color information virtual drawing screen and the attribute information virtual drawing screen for every pixel. Regarding the metacommand pixel, the drawing function obtains pixels to be written by computation. For the reason of these natures, parameters of the command are changed at the application 12d side so that a figure with any size can be drawn. However, when a plurality of commands correspond to one figure as in a character, a pixel serving as noise is sometimes generated. More specifically, a dot is not produced at one scale factor while a useless dot is produced at another scale factor. The dot tends to be produced particularly at a joint of lines drawn with a plurality of commands. It is preferable that no such dot as noise is produced.

[0134] Figs. 29A to 29D show a manner of eliminating noise dot employed in the embodiment. Suppose that an image shown in Fig. 29A is original. The image shows a part of a character and is found to be a corner of a frame-shaped figure. Further, the image is supposed to be a joint of a plurality of drawing commands. However, the image is not necessarily a joint.

Description

FIELD OF THE INVENTION

The present invention relates to an image processing method and an image processing apparatus which are used for an image input/output device such as a digital copying machine and reads an image and divides the read image into blocks composed of a plurality of picture elements so as to perform a variable scaling process on the image by interpolating or thinning out each picture element.

BACKGROUND OF THE INVENTION

Conventionally, in the case where a variable scaling of an input image is performed by a digital copying machine, namely, the input image is enlarged or reduced by a digital copying machine, it is enough to select either of a nearest neighbor interpolation and interpolations of first through third degrees per page.

In the nearest neighbor interpolation, an image is divided into blocks composed of a plurality of picture elements, and when enlarging the image, the data of the picture element existing in the nearest neighborhood of a target picture element is used as data of the target picture element. The enlarging method by means of the nearest neighbor interpolation has a preferable characteristic that an edge of a character becomes clear.

In addition, in the interpolation of first through third degrees, data of a target picture element in divided blocks are determined by using an computing mean of the data of the nearest neighbor picture element of the target picture element and data of another neighbor picture element, which is obtained by formulas of the first through third orders so that an image is enlarged. This method is also called as a linear interpolation. More specifically, the data of the nearest neighbor picture element of the target picture element and the data of another neighbor picture element are respectively weighted with an inverse number of a distance from the target picture element and a weighted mean is obtained. The data obtained from the weighted means is specified as data of the target picture element.

The enlarging method through the interpolations of first through third degrees is preferable as the enlarging process in the case of processing an image in which density gradually changes like a photographic image because new data of a picture element interpolated between the respective picture elements (interpolation picture element data) become means of picture element data existing on both sides adjacent.

However, in the case where two or more types of image data, such as characters, photographs and mesh dots, coexist on one page of image, if a variable magnification of such an image is processed by either of the nearest neighbor interpolation and the interpolations of first through third degrees, image quality of either of the characters, the photographs, etc. is deteriorated.

Therefore, Japanese Unexamined Patent Publication No. 6-286221/1994 (Tokukaihei 6-286221) discloses a printing method which is capable of changing a variable scaling process according to types of data in the case where characters, photographs, mesh dots, etc. coexist on one page.

In this printing method, input data such as character information such as character codes and form information are inputted from a host as an external device into a buffer memory of a printer. The printer creates a character pattern and a form pattern according to the information of the inputted data so as to print an image.

In the case where enlarging or reducing process is executed prior to printing, when a special enlarging or reducing method is cataloged into the printer according to the character pattern, etc., variable scaling is performed by the enlarging or reducing process. Therefore, the variable scaling process can be performed according to each type of data.

However, since the above conventional image processing method is applied to a printer, and the variable scaling process of such a printer can be previously judged by information from an external host that characters, vector drawings and bit images is inputted as image data. Therefore, in image input and output devices such as a copying machine, the above-mentioned image processing method has a disadvantage that in the case where document image is read by a scanner and characters, photographs and mesh dots coexist on one page of the read document image, a variable scaling process cannot be performed according to the type of image data.

SUMMARY OF THE INVENTION

The present invention is invented from a viewpoint of the above conventional problem, and it is an object of the present invention to provide an image processing method and an image processing apparatus which are capable of, even if characters, photographs and mesh dots coexist in an image read by a scanner, preventing a deterioration in image quality by variable scaling the image according to the characters, photographs and mesh dots.

In order to achieve the above object, an image processing method of the present invention for scaling an image is characterized by having: the step of dividing an image into blocks composed of a plurality of picture elements so as to detect region segmentation data, which represent possibilities of characters, photographs and mesh dots in a block of a target picture element, by region segmentation means per target picture element; and the step of computing density of the target picture element on the output image by using computing means according to an equation into which density of a plurality of adjacent picture elements in the vicinity of the target picture element is inputted, wherein in the computing step, a weight of the density of each adjacent picture

element in the equation is adjusted according to the region segmentation data of the target picture element.

In other words, in the case where characters and photographs, etc. coexist in a document image, when the conventional nearest neighbor interpolation or the interpolation of first through third degrees is used for enlarging magnification, the following problems arise. Namely, when the nearest neighbor interpolation is selected, a pseudo-contour occurs on a photograph, and when the interpolation of first through third degrees is selected, an edge of characters becomes unclear.

However, in accordance with the above method, region segmentation data, which represent possibilities of characters, photographs and mesh dots of a target picture element on an image are detected by the region segmentation means, and interpolated picture element data per picture element are computed by the computing means according to the equation in which density of a plurality of adjacent picture elements in the vicinity of the target picture element is inputted. At this time, a weight of the density of each adjacent picture element in the equation is adjusted based upon the result detected by the region segmentation means.

Therefore, a portion where the possibility of characters is strong is enlarged by the nearest neighbor interpolation or the like so that the edge of the enlarged characters can be prevented from becoming unclear. Meanwhile, a portion where the possibility of photographs is strong is enlarged by the interpolation of first through third degrees or the like so that the pseudo-contour can be prevented from occurring on the enlarged photograph.

As a result, even if characters, photographs and the mesh dots coexist on an image read by a scanner, the image is scaled according to the characters, photographs or mesh dots so that deterioration of image quality can be prevented.

It is desirable that the image processing method is such a method that in the detecting step, the region segmentation data are set so as to take a value X which falls the range of 0 to N-1 (N is an integral number not less than 2) and so that as the possibility of characters is stronger, the region segmentation data takes a smaller value and as the possibilities of photographs and mesh dots are stronger, the region segmentation data takes a larger value, and in the computing step, density D_p of a picture element P which is a target picture element whose density should be determined, is computed according to the following equation:

$$D_p = (1-K) \times D_a + K \times D_b \qquad (1)$$

$$(\text{However, } K = (X_p/(N-1)) \times (PA/(PA+PB)))$$

where X_p is region segmentation data of the picture element P, D_a is density of a picture element A which is the closest to the picture element P, D_b is density of a picture element B which is the second closest to the picture element P, PA is a distance between the picture element P and the picture element A, and PB is a distance between the picture element P and the picture element B.

In other words, characters, photographs and mesh dots mostly coexist on an actual image, and when pattern matching or the like is used as a variable scaling method for a target picture element of such an image, a lot of memories are required for performing the variable scaling process delicately, and time required for the process is increased.

However, in accordance with the above method, the computing means computes the density D_p of the picture element P according to the equation (1). In the equation (1), in the case where the region segmentation data X_p obtain a value 0 representing complete characters, for example, K =0 and $D_p = D_a$. Namely, this means the variable scaling process by the nearest neighbor interpolation.

Meanwhile, in the case where the region segmentation data X_p obtains a value N-1 representing complete photograph, for example,

$$D_p = (PB \cdot D_a + PA \cdot D_b) / (PA + PB)$$

Therefore, D_p becomes a linearly weighted mean of the density D_a of the picture element A which is the closest to the picture element P and the density D_b of the picture element B which is the second closest to the picture element P.

Therefore, even if characters, photographs and mesh dots coexist on an image, when the nearest neighbor interpolation or the like is used for a portion where the possibility of characters is strong and a method which is closer to the interpolation of first degree is used for a portion where the possibility of photographs is strong at the time of performing the variable scaling process, a more suitable density of scaling-processed data can be obtained according by a simple summing and multiplying operation of the equation (1) based upon the region segmentation data which represent the possibilities of characters, photographs and mesh dots detected by the region segmentation means. Namely, since density can be selected by outstanding software suitably for the characters, photographs and mesh dots per target picture element, density can be determined quickly and the deterioration of image quality can be prevented by a simple arrangement of hardware.

In addition, it is desirable that the image processing method further has: the step of obtaining picture element density slope data which represent density slope of the picture element P with respect to picture elements which are adjacent to the picture element P after the computing step; and the step of on the picture element P whose region segmentation data X_p is 0 and whose density D_p is half-tone density, and on the picture element A which is the closest to the picture element P, when the picture element density slope data are data representing a relationship $D_a < D_p < D_b$, converting the density D_p into a value obtained by multiplying the half-

tone density and magnification of the variable scaling together, and setting the density D_a to 0, whereas when the picture element density slope data are data representing a relationship $D_b < D_p < D_a$, converting the density D_a into a value obtained by multiplying the half-tone density and magnification together, and setting the density D_p to 0.

In the case where the read image is character data and picture elements in the read position is an edge of the character, the density of this picture element is mostly half-tone density. Then, when the image is subject to the variable scaling process by the summing and multiplying operation in the equation (1), the half-tone density continues, and thus the edge becomes unclear.

However, in accordance with the above method, when the density D_a of the picture element A which is the closest to the picture element P is half-tone density (i.e., larger than 0 and smaller than the maximum density) and the picture element density slope data S_p of the picture element P are data representing a relationship $D_a < D_p < D_b$ (positive), the density D_p is converted into a value obtained by multiplying the half-tone density and magnification together and the density D_a is set to 0, whereas when the density D_a is half-tone density and the picture element density slope data S_p of the picture element P are data representing a relationship $D_b < D_p < D_a$ (negative), the density D_a is converted into a value obtained by multiplying the half-tone density and magnification together, and the density D_p is set to 0.

Therefore, the density of two picture elements in the edge portion of the character data (pulse width for outputting a laser) is subject to the variable scaling process so that the density of the picture element inside a, character is varied according to magnification and the density of the picture element outside the character becomes 0. As a result, the edge portion of the character data is further enhanced, and thus the edge portion of the characters can be prevented from becoming unclear.

It is desirable that the image processing method further has: the step of outputting a laser according to density data with respect to the target picture element after the converting step, wherein in the laser outputting step, a laser is outputted to the target picture element, to which the value obtained by multiplying the half-tone density and the magnification of the various scaling together is given, in a position which is shifted to a side of the picture element where the density is higher based upon the picture element density slope data of the target picture element.

In other words, in the case where the read image is character data and the picture element in the read position is an edge of the image, when the picture element, which was subject to the process of, for example, 8 bits/picture element, has half-tone density, the picture element has the density of 128, i.e., 80H (H represents hexadecimal notation). Therefore, in an image output device which outputs a half-tone image by varying a pulse width of one picture element, the image data of 80H are generated in the central position of the picture element for half dot of one picture element. Then, in the case where the picture element, on which the image data for half dot are generated in its central position, is subject to the enlarging process, a white picture element of half dot appears between the picture element and an adjacent picture element. Such a white picture element continues per picture element, and thus a so-called ghost contour occurs.

However, in accordance with the above method, a laser is outputted for a target picture element, to which the value obtained by multiplying the half-tone density and the magnification together is given, in a position which is shifted to a side of the picture element where the density is higher based upon the picture element density slope data of the target picture element.

Therefore, when the picture element for the edge portion of the character data is subject to the variable magnification process according to magnification via the image processing method, the ghost contour is prevented from occurring on the left or right of one picture element at the edge of the character data.

It is desirable that the image processing method is a such a method that in the computing step, when the data of each interpolated picture element is computed by the computing means, the region segmentation data detected by the region segmentation means is variably scaled so as to be outputted together with the scaling-processed image data.

In other words, in the case where the image data which was subject to variable scaling process are desired to be outputted into an external asynchronous image input/output device, such as a facsimile and a personal computer, together with the region segmentation data, for example, if also the region segmentation data is not subject to the variable scaling process, a number of picture elements of the scaling-processed image data does not agree with that of the region segmentation data. For this reason, the region segmentation data cannot be used.

However, in accordance with the above method, the region segmentation data detected by the region segmentation means are also subject to the variable scaling process based upon the result detected by the region segmentation means so as to be outputted together with the scaling-processed image data.

Therefore, a number of picture elements of the magnification varied image data can agree with that of the region segmentation data. As a result, in the case also where these data are outputted to an external asynchronous image input/output device such as a facsimile and a personal computer, the region segmentation data can be used.

It is desirable that the variable scaling process for the region segmentation data in the computing step is performed based upon the result detected by the region segmentation means.

As a result, since the data representing the possibilities of characters, photographs and mesh dots are

given also to the scaling-processed region segmentation data, the scaling-processed image can be outputted to an external image input/output device such as a facsimile and a personal computer by combining these data with the region segmentation data.

It is desirable that the image processing method further has: the step of simultaneously outputting the scaling-processed image data and the scaling-processed region segmentation data after the computing step, wherein in the outputting step, directing data, which represent a front and a rear of each line of plural picture elements on the output data and end of the image data, together with the scaling-processed image data and the scaling-processed region segmentation data.

In other words, in the case where the scaling-processed image data are outputted to an external asynchronous image input/output device such as a facsimile and a personal computer, when the data, which represent the front and rear of the line and the end of the image data, do not exist in the magnification varied region segmentation data, a number of picture elements of one line and a total number of lines should be transmitted to other external asynchronous image input/output device. Moreover, even in the case where this transmission is executed, a line counter should be always provided.

However, in accordance with the above method, since the directing data, which represent the front and the rear of each line of a plurality of picture element on the output data and the end of the image data, are simultaneously outputted, a number of picture elements for one line and a total number of lines does not have to be transmitted to an external synchronous image input/output device. Furthermore, installation of a line counter can be avoided.

An image processing apparatus of the present invention for scaling inputted image so as to output the scaling-processed image is characterized by having: region segmentation means for dividing the input image into blocks composed of a plurality of picture elements and detecting region segmentation data, which represent possibilities of characters, photographs and mesh dots of a block of a target picture element per target picture element; and computing means for computing density of the target picture element on the output image by using an equation in which density of a plurality of adjacent picture elements in the vicinity of the target picture element is inputted,

wherein the computing means adjusts a weight of the density of each adjacent picture element in the equation according to the region segmentation data of the target picture element.

In accordance with the above arrangement, the region segmentation data, which represent the possibilities of characters, photographs and mesh dots on the image, are detected by the region segmentation means, and the interpolated picture element data per picture element are computed by the computing means according to the equation in which the density of a plurality of adjacent picture elements in the vicinity of the target picture element is inputted. At this time, a weight of the density of each adjacent picture element in the equation can be adjusted based upon the result detected by the region segmentation means.

Therefore, the portion where the possibility of characters is strong is enlarged by the nearest neighbor interpolation or the like so that the edge of the enlarged characters can be prevented from becoming unclear. Meanwhile, the portion where the possibility of photograph is strong is enlarged by the interpolation of first through third degrees or the like so that a pseudo-contour is prevented from occurring on the enlarged photograph.

As a result, even in the case where characters, photographs and mesh dots coexist in an image read by a scanner, deterioration of image quality can be prevented by the variable scaling process according to the characters, photographs and mesh dots.

For fuller understanding of the nature and advantages of the invention, reference should be made to the ensuing detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram which shows an arrangement of a digital copying machine as an image processing apparatus which adopts an image processing method according to one embodiment of the present invention.

FIG. 2 is an explanatory drawing which explains an image processing function of the digital copying machine.

FIG. 3 is an explanatory drawing which shows a computing process of a variable scaling section in the digital copying machine.

FIG. 4 is a block diagram which shows an output control section and an image output section in the digital copying machine.

FIGS. 5(a) through 5(c) are explanatory drawings which show output examples of a pulse width modulator on each picture element: FIG. 5(a) is a drawing which shows an output of the pulse width modulator in the case where half-tone data are outputted shifted to the left; FIG. 5(b) is a drawing which shows an output of the pulse width modulator in the case where half-tone data are outputted shifted to the right; and FIG. 5(c) is a drawing which shows an output of the pulse width modulator in the case where half-tone data are outputted being centered.

FIG. 6 is a graph which shows an original image having tone.

FIG. 7 is a graph which shows density of read picture elements when the original image shown in FIG. 6 is read.

FIG. 8 is a graph which shows an output in the case of using a nearest neighbor interpolation when the read

picture elements shown in FIG. 7 are enlarged by twice.

FIG. 9 is a graph which shows an output in the case of using interpolation of first degree when the read picture elements shown in FIG. 7 are enlarged by twice.

FIG. 10 is a graph which shows read density data when an image in which characters and photographs coexist is read.

FIG. 11 is a graph which shows an output in the case of using the nearest neighbor interpolation when the read picture elements shown in FIG. 10 are enlarged by twice.

FIG. 12 is a graph which shows an output in the case of using the interpolation of first degree when the read picture elements shown in FIG. 10 are enlarged by twice.

FIG. 13 is a graph which shows an output in the case of using the nearest neighbor interpolation in a section judged to be characters and using the interpolation of first degree in a section judged to be a photograph when the read picture elements shown in FIG. 10 are enlarged by twice.

FIG. 14 is a graph which shows read density data when an image in which characters and photographs coexist is read.

FIG. 15 is a graph which shows an output in the case of using the nearest neighbor interpolation when the read picture elements shown in FIG. 14 are reduced to half.

FIG. 16 is a graph which shows an output in the case of using the interpolation of first degree when the read picture elements shown in FIG. 14 are reduced to half.

FIG. 17 is a graph which shows an output in the case of using the nearest neighbor interpolation in a section judged to be characters and using the interpolation of first degree in a section judged to be a photograph when the read picture elements shown in FIG. 14 are reduced to 1/2.

FIG. 18 is a graph which shows an output in the case of giving an edging process to a section judged to be characters in FIG. 13.

FIGS. 19(a) through 19(c) are explanatory drawings which show effects of an ON signal position operation in the picture elements by means of the pulse width modulator: FIG. 19(a) is a drawing which shows density values (256 tones) of the picture elements; FIG. 19(b) is a drawing which shows an output when a picture element density slope data is fixed to the center; and FIG. 19(c) is a drawing which shows an output when the pulse width is outputted shifted to the side where the density is high based upon data representing the density slope.

FIG. 20 is a block diagram which shows an arrangement of the digital copying machine which adopts an image processing method according to another embodiment of the present invention.

FIG. 21 is a block diagram which shows an arrangement of a variable scaling section in the digital copying machine.

FIGS. 22(a) and 22(b) are explanatory drawings which show states that when scaling-processed image data and scaling-processed region segmentation data are outputted simultaneously, their respective directing data are outputted simultaneously: FIG. 22(a) is a drawing which shows the front of each line of each data inputted to the variable magnification processing section; and FIG. 22(b) is a drawing which shows the front of each line of each data outputted from the variable magnification processing section.

FIGS. 23(a) and 23(b) are explanatory drawings which show states that when scaling-processed image data and scaling-processed region segmentation data are outputted simultaneously, their respective directing data are outputted simultaneously: FIG. 23(a) is a drawing which shows the rear of each line of each data inputted to the variable scaling section; and FIG. 23(b) is a drawing which shows the rear of each line of each data outputted from the variable scaling section.

FIGS. 24(a) and 24(b) are explanatory drawings which show states that when scaling-processed data and scaling-processed region segmentation data are outputted simultaneously, their respective directing data are outputted simultaneously: FIG. 24(a) is a drawing which shows an end portion of an image data of each data inputted into the variable scaling section; and FIG. 24(b) is a drawing which shows an end portion of image data of each data outputted from the variable magnification processing section.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[EMBODIMENT 1]

The following describes one embodiment of the present invention on reference to FIGS. 1 through 17.

As shown in FIG. 1, a digital copying machine as an image processing apparatus of the present embodiment is provided with an image input section 1, a shading correcting/automatic exposing section 2, a region segmentation section 3 as region segmentation means, a variable scaling section 4 as computing means, a γ correcting section 5, an output control section 6 and an image output section 7.

The image input section 1 reads a document image from a scanner, not shown, so as to convert the read image into digital input image data 1a. The shading correcting/automatic exposing section 2 processes shading correction and automatic exposure of the input image data 1a.

While referring to density, etc. of picture elements in the vicinity of target picture elements of the image data 2a which were subject to the shading correction and the automatic exposure, the region segmentation section 3 detects a possibility of characters, a possibility of photographs and a possibility of mesh dots of the target picture elements of the image data 2a so as to output image data 3a and region segmentation data 3b.

The region segmentation data 3b, which represents

the possibilities of characters, photographs and mesh dots, take a value X which falls within the range of 0 to N-1 (N: an integral number not less than 2). The smaller the value X is, the stronger the possibility of characters is, and the larger the value X is, the stronger the possibilities of photographs and mesh dots are. In the present embodiment, N=8, for example, is adopted. Therefore, when the possibilities of photographs and mesh dots are the strongest, the region segmentation data 3b take the value X=7.

The following describes a technique of detecting the possibilities of characters, photographs and mesh dots in each picture element. The possibilities of characters, etc. can be detected by the prior art, but in the present embodiment, a few improvements are made on the prior art.

As the prior art, for example, there exists an art of dividing an image into blocks composed of a plurality of picture elements and identifying the image per block by using pattern matching or feature parameters which represent properties of a character image and a mesh dot image so as to detect the possibilities of characters, etc.

Since the image identification method using the pattern matching requires preparation of many patterns, there arises a problem that a memory capacity becomes enormous and that this method lacks versatility. For this reason, the image identification method using the feature parameters is adopted increasingly at present.

As the image identification method using the feature parameters, Japanese Unexamined Patent Publication No. 61-194968/1986 (Tokukaisho 61-194968) discloses a mesh dot photographic region identification method of individually measuring changes in signal levels of two picture elements which spatially continue in the two cases where the two picture elements continue in a horizontal scanning direction and continues in a vertical scanning direction and comparing sum totals of measured amounts in the blocks respectively with predetermined values so as to identify the image according to the compared results.

In addition, as another method using the feature parameters, Japanese Unexamined Patent Publication No. 62-147860/1987 (Tokukaisho 62-147860) discloses a half-tone facsimile signal processing method. In this method, a difference between a maximum signal level and a minimum signal level in the blocks is obtained, and the difference value is compared with a predetermined value. Then, when the level difference is smaller than the predetermined value, a judging signal, which represents that the signal level in a section including a photograph is changed mildly, is outputted, whereas when the level difference is larger than the predetermined value, a judging signal, which represents that the signal level in a section including contour of characters and a photograph or a mesh dot photograph is changed intensely, is outputted. Moreover, a number of changes between the two signal levels of the two picture elements which continues spatially is compared with a predetermined value according to order of access which is predetermined in the blocks, and according to the compared results, when the number of changes is larger than the predetermined value, a judging signal, which represents that the block is a mesh dot section, is outputted, whereas when the number of changes is smaller than the predetermined value, a judging signal, which represents that the block is not a mesh dot section, is outputted. Then, the picture elements in the blocks are subject to a signal process according to the respective judging signals.

An image process which improves image quality, a space filtering process is conventionally used. As an image processing method for improving the image quality by using the filtering process, for example, Japanese Examined Patent Publication No. 5-147860/1993 (Tokukohei 5-147860) discloses a half-tone facsimile signal processing method. In this method, a space filter which makes an image signal smooth and a space filter which enhances an image signal are prepared, and a signal, which smoothed the image signal and/or a signal which enhanced the image signal are/is mixed or selected based upon an output of edge detecting means which detects an edge section of the image signal. Moreover, another method is disclosed in Japanese Unexamined Patent Publication No. 63-246076/1988 (Tokukaisho 63-246076). In this method, a space filter, such as a filter processing device, which removes a mesh dot component is prepared, and when an edge section is not extracted by edge extracting means which extracts an edge section of an image signal, a signal, which has been subject to the filtering process for removing the mesh dot component, is outputted, whereas when an edge section is extracted, a signal, which has not been subject to the filtering process yet, is outputted.

However, the above-mentioned conventional image identification method has a disadvantage that misjudgment of the image identification occurs.

The cause for the misjudgment of the image identification is considered to be unsuitable feature parameters, namely, the feature parameters do not sufficiently represent respective properties of the regions. Besides, unsuitable classifying method for the image identification according to an amount of features obtained by the feature parameters and unsuitable selection of a threshold value for the classification also cause the misjudgment of the image identification.

In the conventional method of classifying and identification the blocks according to an amount of features obtained by the feature parameters so as to execute the filtering process on target picture elements in the blocks using a prepared space filter according to the identified results, great influence is exerted on image quality at the time of misjudgment, and an amount of features owned by the target picture elements reflects only limited filter characteristics. For this reason, there arises a problem that a delicate process such as the filtering process cannot be performed most suitably for the tar-

get picture elements.

Therefore, in the present embodiment, as disclosed in the U.S. patent application Serial No. 08/540,580 (Japanese Patent Application No. 6-264232/1994) by the inventors of the present invention, an image signal obtained by scanning a document is subject to an identification process which identifies as to whether each picture element exists in a character region, a photographic region or a mesh dot region, and when each picture element is subject to an image process according to the results of the identification process, certain picture element data of the image signal is used as a target picture element, and image data in a local block, which composed of the target picture element and a plurality of picture elements in the vicinity of the target picture element, are stored in a block memory.

Next, according to the image data in the local block stored in the block memory, a plurality of feature parameters, which respectively represent features of the character region, the photographic region and the mesh dot region, is obtained. A multi-dimensional identification process is executed by identification means which selects each of the character region, the photographic region and the mesh dot region divided by borderlines including a non-linear characteristics in a multi-dimensional plane including axis of the above feature parameters and which is composed of a neural network which learned beforehand for receiving each feature of the plural feature parameters and outputting region identification information according to each input. Namely, the identification process is performed not by setting a threshold value for each feature parameter but based on the borderlines including non-linear characteristic based on which the multi-dimensional space is divided by feature parameters.

According to the described method, even if an identification cannot be performed with a desired accuracy when considering only one feature parameter, by taking plural feature parameters into consideration, the identification of the region where the target picture element is located can be performed with an improved accuracy. Furthermore, as a multi-dimensional identification process is performed using a neural network which receives each input of plural parameters, an identification can be performed with very high precision.

In addition, the region identification information outputted by the identification means is data which respectively, represent likelihoods of the character region, the photographic region and the mesh dot region in a region of the block in which the target picture element exists by numerals. Namely, the identification means outputs a possibility of characters which is a numeral representing a character region in a region of a block where a target picture element exists, a possibility of photographs which is a numeral representing a photographic region in a region of a block where a target picture element exists, and a possibility of mesh dots which is a numeral representing a photographic region in a region of a block where a target picture element exists.

According to the above manner, the possibilities of characters, photographs and the mesh dots in each picture element are detected. Then, data, which are used for obtaining the possibilities of characters, photographs and mesh dots from the feature parameters (for example, a difference between the maximum density value and the minimum density value in a certain block for picture elements in the vicinity of the target picture element), are region segmentation data, and the region segmentation data are determined by the aforementioned method.

Then, as mentioned above, in the present embodiment, the above-mentioned data, namely, the region segmentation data 3b, can take a value X which falls within the range of 0 to N-1 (N: an integral number of not less than 2).

In the space filtering process suggested in the U.S. Patent Application Serial No. 08/540,580, various filters in which filter coefficients were predetermined are selected based upon the identification signal. More concretely, the filter coefficients are determined per processed picture element based upon the data representing likelihood of each region by numerals so that the space filtering process is performed.

Next, the variable scaling section 4 performs the variable scaling process on the inputted image data 3a and region segmentation data 3b, namely, enlarges or reduces of the inputted image data 3a and region segmentation data 3b so as to output scaling-processed image data 4a which are scaling-processed image data, and magnification varied region segmentation data 4b which are scaling-processed region segmentation data, and judges slope of density of a current picture element by referring to peripheral picture elements so as to output special data 4c.

At the time of the variable scaling process, interpolation represented by an operation expression, mentioned later, is used as the image data 3a, and nearest neighbor interpolation is used for processing the region segmentation data 3b. Moreover, the special data 4c are composed of directing data, which represent the front and rear of a line of the region segmentation data 3b and end of the image data, and data, which represents slope of density of a picture element being processed currently (i.e., "picture element density slope data").

In addition, the picture element density slope data are outputted as data representing "No slope" except that the region segmentation data 3b has a strong possibility of characters. Namely, the variable scaling section 4 outputs "No slope" as the picture element density slope data except that the region segmentation data 3b has a value representing a strong possibility of characters (here, 0).

Since the variable scaling process for an image in the vertical scanning direction of a digital copying machine is adjusted by changing a speed of an optical system, the image data 3a is subject to the variable scaling process by the variable magnification process-

ing section 4 in only the horizontal scanning direction of the digital copying machine.

The γ correcting section 5 performs the γ correcting process on the inputted scaling-processed image data 4a.

The output control section 6 is also called as a pulse width modulator, and controls an output of an image. The image output section 7 outputs a laser based upon a signal of the output image data 6a inputted to the image output section 7.

In the digital copying machine of the present embodiment, the input image data 1a, the image data 2a and 3a, the scaling-processed image data 4a and the scaling-processed γ corrected image data 5a are respectively composed of 8 bits per picture element (namely, each picture element takes a value of 256). Moreover, the output image data 6a is aggregate of signals with 256 pulses per picture element. The output control section 6 creates data as to how many pulses of 256 pulses obtained by dividing one picture element into 256 is turned on, based upon a value of the inputted scaling-processed γ corrected image data 5a, and represents density by outputting the created data.

In addition, the region segmentation data 3b and the scaling-processed region segmentation data 4b are respectively composed of 3 bits per picture element (namely, each picture element takes a value of 8). Further, the special data 4c are composed of a total of 5 bits: 2 bits of the directing data representing the front and rear of a line and end of image data; and 3 bits of the picture element density slope data in a picture element being processed currently. Moreover, the special data 4c are combined with the scaling-processed region segmentation data 4b so as to take a value of 8 bits per picture element.

The following describes an image processing method relating to the variable scaling process in the digital copying machine having the above arrangement.

As shown in FIG. 2, when density in a position P of a picture element after the variable scaling process, namely, output picture element density D_p is determined, a simple summing and multiplying operation is performed by using a picture element A which has density D_a and region segmentation data X_a, and is the nearest to the picture element P (i.e., "nearest neighbor picture element"), a picture element B which has density D_b and region segmentation data X_b and is the second nearest to the picture element P (i.e., "second nearest neighbor picture element"), and distances PA and PB between the picture elements P, A and B.

The above summing and multiplying operation is performed in the variable scaling section 4.

As shown in FIG. 3, the region segmentation data X_a and the density D_a in the nearest neighbor picture element A, and the region segmentation data X_b and the density D_b in the second nearest neighbor picture element B are inputted into the variable scaling section 4. Outputs of the variable scaling section 4 are output picture element region segmentation data X_p as the magnification varied region segmentation data 4b, output picture element density D_p, data representing a position of the output picture element used in the output control section 6, i.e., the picture element density slope data S_p, and bits for controlling the directing data representing the front and rear of a line and the end of an image data.

In the variable scaling section 4, when the output picture element region segmentation data X_p is computed, a relationship $X_p = X_a$ is fulfilled by the nearest neighbor interpolation. Namely, the nearest neighbor interpolation directly uses data of a picture element exist in the nearest neighbor as the output data of picture element.

Meanwhile, the output picture element density D_p is computed according to the following equation.

$$D_p = (1-K) \times D_a + K \times D_b \tag{1}$$

$$(\text{Here, } K = (X_p/N-1) \times (PA \, / \, (PA + PB)) \tag{2}$$

In the present embodiment, since a number of separations of the region segmentation data is set to 8, the value N-1 in the equation (2) is computed according to the equation N-1 = 8 - 1 =7.

When the output picture element region segmentation data X_p takes a value representing that the possibility of characters is strongest, namely, $X_p = 0$, the equation (1) becomes as follows:

$$D_p = D_a$$

and thus the equation (1) represents the nearest neighbor interpolation. Namely, the nearest neighbor interpolation directly uses the density of the picture element A as the density of the output picture element D.

In addition, when the output picture element region segmentation data X_p takes a value representing the strongest possibility of photographs, namely, $X_p = N-1 = 7$, the equation (1) becomes as follows:

$$D_p = (PB \cdot D_a + PA \cdot D_b) \, / \, (PA + PB)$$

and thus the equation (1) represents the interpolation of first degree. Namely, the interpolation of first degree uses linearly weighted mean of weighing the density of the picture element A with the density of the picture element B as the density of the output picture element D is determined.

Next, when $X_p = 0$, namely, the block of a picture element is judged to be characters in the region segmentation process, the relationship $D_a < D_p < D_b$ is fulfilled. Moreover, when D_p is on the left side of D_a, data representing the position of an output picture element in one picture element, i.e., the picture element density slope data S_p the picture element density slope data S_p becomes data representing that a picture element is outputted in a position which is shifted to the left, namely, S_p = 01B (B is binary display).

Meanwhile, when $X_p = 0$, $D_a > D_p > D_b$, and D_p is on the right side of D_a, S_p becomes data representing that a picture element is outputted in a position which is shifted to the right, namely, $S_p = 10B$. Furthermore, when $X_p = 0$ and the condition of D_a, D_b and D_p is other than the above, S_p becomes data representing that a picture element is outputted in a central position, namely, $S_p = 00B$.

In addition, when $X_p \neq 0$, namely, the picture element density slope data S_p are judged not to be characters in the region segmentation process, S_p becomes data representing that a picture element is outputted in the central position, namely, $S_p = 00B$.

When output picture element P is a front or rear of a line or an end of a page, corresponding directing data are added to the picture element density slope data S_p so that the special data 4c are outputted.

As shown in FIG. 1, the data of the output picture elements P, namely, the scaling-processed image data 4a, the scaling-processed region segmentation data 4b and the special data 4c are respectively inputted to the output control section 6 after the scale-processed image data 4a is subject to the γ correction.

The following describes a detailed operation of the output control section 6.

As shown in FIG. 4, in the output control section 6, a pulse width is modulated by the pulse width modulator 16.

Inputs of the pulse width modulator 16 are image data of 8 bits per picture element which are composed of the scaling-processed γ corrected image data 5a and the magnification varied region segmentation data 4b, and picture element density slope data of 3 bits per picture element which are included in the special data 4c.

The image data and the picture element density slope data are synchronously inputted to the pulse width modulator in parallel. Outputs of the pulse width modulator 16 are serial video data which are divided into 256 per picture element. The pulse width modulator 16 control a laser of the image output section 7 according to pulses of an ON signal of 1/256 picture element based upon the input image data of 8 bits per picture element, namely, with value of 256, and controls the density of one picture element by 256 steps.

In addition, the pulse width modulator 16 refers to the density slope data so as to determine a position of one picture element where continuous ON signals are allowed to be generated. Namely, when the picture element density slope data S_p of 3 bits per picture element are 01B which represents that they are shifted to the left, the continuous ON signals are allowed to be generated at the front of the picture element, and when the picture element density slope data are 10B which represents that they are shifted to the right, the continuous ON signals are allowed to be generated at the rear of the picture element. Moreover, when the picture element density slope data S_p are 00B which represents that they are centered, the continuous ON signals are allowed to be generated at the center of the picture element.

More concretely, as shown in FIG. 5(a), when input image data are 80 H, i.e., have 128/256 density, and the input picture element density slope data of the special data are 10B, namely, they are shifted to the left, half (128/256) picture element from the front of the picture element is turned on, and the rest of half picture element is turned off.

In addition, as shown in FIG. 5(b), when input image data are 80 H, i.e., have 128/256 density, and the input picture element density slope data of the special data are 01B, namely, they are shifted to the right, half (128/256) picture element from the front of the picture is turned off, and the rest of a half picture element is turned on.

Furthermore, as shown in FIG. 5(c), input image data are 80 H, i.e., have 128/256 density, and the input image density slope data of the special data are 00B, namely, they are centered, one-fourth (64/256) picture element from the front of the picture element is turned off, a next half picture element is turned on, and the rest of one-fourth picture element is turned off.

In such a manner, the pulse width modulator 16 adjusts outputs of the laser so as to change a position of ON data within one picture element.

The following details a variable scaling process of an image with variable density, i.e., an image with density tone according to the equation (1).

An example is given as to an original image having density tone shown in FIG. 6. A vertical axis represents the density of the original image. In this case, when the original image is a white image, the density value is 0, and when the original image is a black image, the density value is 255. Moreover, a horizontal axis represents a position where the above density is obtained.

When an original image having density tone shown in FIG. 6 is read by the image input section 1, as shown in FIG. 7, the original image is divided according to each picture element. A vertical axis in FIG. 7 represents density values, which are integral numbers of 8 bits, i.e., 0 to 255. On the horizontal axis, the position in FIG. 6 is divided by a unit of one read picture element, and rectangles of the graph respectively represent the density values of the read picture elements per read picture element unit.

Next, when the read picture elements shown in FIG. 7 are enlarged twice by using the nearest neighbor interpolation, the read picture elements are represented by FIG. 8. In FIG. 8, a vertical axis represents density values which are integral numbers of 8 bits, i.e., 0 to 255. Moreover, a horizontal axis represents a position in a write picture element unit. Further, rectangles of the graph respectively represent density values of a write picture element in a unit of one write picture element.

Since the variable scaling process in this case is the nearest neighbor interpolation, data, in which a rectangle with the same shape is arranged next to each rectangle of the read picture element unit shown in FIG. 7, namely, data, in which two picture elements having

the same density make a pair, are obtained. According to this method, an image having a comparatively clear edge is obtained for a binary image such as characters. However, a variation of the density cannot be precisely reproduced for an image such as a photographic image whose density is successively changed. As a result, a so-called pseudo-contour is caused.

Here, the pseudo-contour is a contour which is caused when continuity of variation of density in a variable density image is lost, and does not exist in an original image (see p. 481 "Handbook of Image Analysis", first edition published by the Publishing Foundation, the University of Tokyo: the supervision of Mikio Takagi and Shimoda).

Therefore, as for an image such as a photographic image whose density is successively changed, it is preferable that the variable scaling process is performed by using the interpolation of first degree.

In other words, the original image read data shown in FIG. 7 are enlarged twice by using the interpolation of first degree, they are represented FIG. 9.

According to the interpolation of first degree, a picture element having density, which is the same as a mean of densities of two read image data, is interpolated between the two continuous read image data. According to this method, as for an image such as a photographic image whose density is successively changed, the variation of density of the original image can be reproduced comparatively definitely and faithfully, but as for a binary image such as characters, an image whose contour is not clear is reproduced.

Therefore, in the case where characters, photographs, etc. coexist in an image, if the nearest neighbor interpolation or the interpolation of first degree is selected indiscriminately, there arises a problem.

This is described concretely on reference to the drawings.

First, read density data which is obtained by reading an image in which characters and photographs coexist are shown in FIG. 10, for example. The left half of FIG. 10 illustrates a character region, and its feature is such that the density changes rapidly. On the contrary, the right half of FIG. 10 illustrates a photographic region, and its feature is such that the density changes continuously and comparatively mildly.

When the read image is enlarged twice by the nearest neighbor interpolation, the image represented by FIG. 11 is obtained.

In this case, since the nearest neighbor interpolation is used, the edge of the left half, namely, the character region of the image is comparatively emphasized, and thus the image becomes clear. However, the right half, namely, the photographic region has unsatisfactory tone production, and thus a pseudo-contour is liable to be caused.

Meanwhile, when the read image shown in FIG. 10 is enlarged twice by the interpolation of first degree, the image represented by FIG. 12 is obtained.

In this case, the interpolation of first degree causes an image whose left half, namely, character region has an unclear edge. However, the right half, namely, the photographic region has satisfactory tone production, and thus a pseudo-contour is difficultly caused.

In such a manner, it is not preferable that the nearest neighbor interpolation or the interpolation of first degree is indiscriminately selected for a whole image.

Therefore, in the present embodiment, in the case where characters and photographs coexist in a read image, the nearest neighbor interpolation or the like is used for the characters, and the interpolation of first degree or the like is used for the photographs.

The following describes the variable magnification process using the above methods.

In other words, in the present embodiment, the region segmentation section 3 detects possibilities of characters, photographs and mesh dots on a picture element so as to output the detected possibilities as the region segmentation data 3b. Then, calculation is made according to the equation (1) based upon the region segmentation data 3b. When the output picture element region segmentation data X_p takes a value representing the strongest possibility of characters, namely, $X_p = 0$, the equation (1) becomes as follows:

$$D_p = D_a$$

and thus the nearest neighbor interpolation is used. Moreover, when the output picture element region segmentation data X_p takes a value representing the strongest possibility of photographs, namely, $X_p = 7$, the equation (1) becomes as follows:

$$D_p = (PB \cdot D_a + PA \cdot D_b) / (PA + PB)$$

and thus the interpolation of first degree is used.

An output image obtained by the above computation is shown in FIG. 13. In other words, FIG. 13 is a graph which shows outputs in the case where when the read picture element shown in FIG. 10 is enlarged twice according to the region segmentation data 3b, two kinds of the variable scaling processes are used. Namely, when the picture element is judged to be a character section, the nearest neighbor interpolation is used, and when the picture element is judged to be a photographic section, the interpolation of first degree is used.

In this case, on the section which was judged to be the character section in the region segmentation section 3, namely, the left section, the edge is enhanced by using the nearest neighbor interpolation as the variable scaling method, and thus a clear image is obtained. Moreover, in the region segmentation section 3, when the interpolation of first degree is used as the variable scaling method for the section which was judged to be a photographic section, namely, the right half, the tone production becomes satisfactory, and thus a pseudo-contour is difficultly caused.

In such a manner, at the time of variable magnification process, referring to the region segmentation data

3b, the variable magnification process which is closer to the nearest neighbor interpolation is used on a section with the strong possibility of characters, and the variable magnification process which is closer to the interpolation of first degree is used on a section with the strong possibility of photographs. As a result, the density data which is scaling-processed can be made the most suitable.

As mentioned above, in the image processing method of the present embodiment which reads an image and divides the read image into blocks composed of a plurality of picture elements and performs a variable scaling process such as enlargement and decreasing of an image by making interpolation per picture element, possibilities of characters, photographs and mesh dots on each picture element on the image are detected by the region segmentation section 3, and interpolated picture element data per picture element are calculated by the variable scaling section 4 based upon the results of the detection so that scaling of the image is performed.

In other words, in the conventional method of selecting the nearest neighbor interpolation or the interpolation of first through third degrees, at the time of the enlarging process of the variable scaling process, i.e., enlargement, when the nearest neighbor interpolation is selected for the case where characters, photographs, etc. coexist in a document image, a pseudo-contour is occasionally caused on the photograph region, and when the interpolation of first through third degrees is selected, an edge of the characters becomes unclear.

However, in accordance with the above method, the possibilities of characters, photographs and mesh dots on each picture element on an image are detected by the region segmentation section 3, and the interpolated picture element data per picture element are computed by the variable scaling section 4 based upon the detected results so that scaling of the image is performed.

Therefore, a section with the strong possibility of characters is enlarged by the nearest neighbor interpolation or the like, and thus an edge of the enlarged characters is prevented from becoming unclear. Meanwhile, a section with the strong possibility of photographs is enlarged by calculation which is closer to the interpolation of first through third degrees, and thus a pseudo-contour of the enlarged photograph is prevented from being caused.

As a result, even if characters, photographs and mesh dots coexist on an image read by a scanner, a deterioration in image quality can be prevented by scaling the image according to the characters, photographs or the mesh dots.

In addition, in the image processing method of the present embodiment, the region segmentation data representing the possibilities of characters, photographs and mesh dots detected by the region segmentation section 3 can take a value X which falls within a range of 0 to N-1 (N is an integral number of not less than 2) (the smaller the value X is, the stronger the possibility of characters is, and the larger the value X is, the stronger the possibility of photographs or mesh dots). Moreover, when the region segmentation data of an interpolation picture element P whose density is should be determined is represented by X_p, the density of the picture element A which is the closest to the picture element P is represented by D_a, the density of the picture element B which is the second closest to the picture element P is represented by D_b, a distance between the picture elements P and A is represented by PA, and a distance between the picture elements P and B is represented by PB, the variable magnification processing section 4 computes the density D_p of the picture element P according to the aforementioned equation (1).

In other words, sections of characters and sections of photographs and mesh dots mostly coexist on an actual image, and thus if the variable magnification method such as pattern matching is used for each picture element of the above-mentioned image, there arises problems that a lot of memories are required for performing precise variable magnification process and that the processing time becomes longer.

However, in accordance with the above method, the variable magnification processing section 4 performs the computation according to the equation (1). Then, in the equation (1), if the region segmentation data X_p take a value 0 representing complete character, $K = 0$ and $D_p = D_a$. Namely, this means the variable scaling process by means of the nearest neighbor interpolation.

Meanwhile, if the region segmentation data X_p takes a value N-1 representing a perfect photograph, for example, the density D_p becomes as follows:

$$D_p = (PB \cdot D_a + PA \cdot D_b) / (PA + PB)$$

and thus D_p becomes a weighted linearly arithmetic means of the density D_a of the picture element A which is the closest to the picture element P and the density D_b of the picture element B which is the second closest to the picture element P. Namely, this means the variable scaling process by means of the interpolation of first degree.

If the region segmentation data X_p takes a value between the possibilities of characters and photographs which fall within a range of more than 0% to less than 100%, the density can be calculated based upon the weight according to the equation (1).

Here, when the weighted linearly arithmetic means of D_a and D_b is represented by D_{ab}, the aforementioned equation (1) can be changed as follows:

$$D_p = \{1-(X_p / (N-1))\} \times D_a + (X_p / (N-1)) \times D_{ab}$$

As is clear from the above equation, when N is an integral number of not less than 3, the region segmentation data X_p fulfills a relationship $0 < X_p < N-1$, namely, obtains a value between the possibilities of characters and photographs which falls within a range

of more than 0% to less than 100%, D_p becomes a weighted linearly arithmetic mean of D_a and D_{ab}. Then, as X_p is smaller, D_p takes a value which is closer to D_a, and as X_p is larger, D_p takes a value which is closer to D_{ab}.

Therefore, even if characters and photographs or mesh dots coexist in an image, during the variable scaling process, a simple summing and multiplying operation represented by the equation (1) is performed based upon the region segmentation data which represent the possibilities of characters, photographs and mesh dots detected by the region segmentation means. More specifically, the variable scaling method which is closer to the nearest neighbor interpolation is used for the section with the strong possibility of characters (X_p is small), and the variable scaling method which is closer to the interpolation of first degree is used for the section with the strong possibility of photographs (X_p is large). As a result, more suitable density can be determined for the magnification varied data. Namely, since the density can be determined suitably for the characters, photographs or mesh dots on each picture element by excellent software, the density can be determined quickly by a simple arrangement of hardware, and a deterioration in image quality can be prevented.

In the present embodiment, the interpolation of first degree is used for determining density, but the method is not limited to this, and thus the interpolation of second or third degree can be used, for example.

In addition, the above explanation refers to the enlarging process of the variable magnification process, but the image processing method of the present embodiment is not necessarily limited to this, and thus this process can be applicable to the case where decreasing process is performed.

For example, when an image in which characters and photographs coexist is read, the read image data are represented by a graph shown in FIG. 14. The left half of FIG. 14 shows a character region where the density changes rapidly, and the right half shows a photographic region in which density changes continuously and comparatively mildly.

When the nearest neighbor interpolation, in which density of a picture element existing in the nearest neighborhood of a target picture element of a reduced image is used as the density of the target picture element, is used for the whole image at the time of reducing the read image data to half, an output image shown in FIG. 15 is obtained. Namely, in the left half of the output image, i.e., the character region, an edge is enhanced comparatively, and thus the image becomes clear, but in the right half, i.e., the photographic region, tone production is deteriorated, and thus a pseudo-contour is liable to be caused.

In addition, when the read image data shown in FIG. 14 are reduced to half by the interpolation of first degree which uses a weighted linearly arithmetic mean of the density of a picture element which exists in the nearest neighborhood of a target picture element of an output image and the density of a picture element which is the second closest to the target picture element as the density of the target picture element, an output image shown in FIG. 16 is obtained. Namely, in the right half of the output image, i.e., the photographic region, the tone production becomes satisfactory, and thus the pseudo-contour is hardly caused, but in the left half, i.e., the character region, an edge becomes unclear.

Therefore, in the present embodiment, when the region segmentation data are judged to be the character section, the nearest neighbor interpolation is used, and when the region segmentation data are judged to be the photographic section, the interpolation of first degree is used. A graphic of output image data obtained by the above method is shown in FIG. 17. In the left half of the FIG. 17, i.e., the region judged to be the character section, the edge is enhanced, and thus a clear image is obtained, and in the right half, i.e., the region judged to be the photographic section, the tone production becomes satisfactory, and thus a pseudo-contour is hardly caused.

In such a manner, the region segmentation data is referred to at the time of the reducing, and the variable magnification processing method which is closer to the nearest neighbor interpolation is used in a section with the strong possibility of characters, and the variable magnification method which is closer to the interpolation of first degree is used in a section with the strong possibility of photographs. As a result, the density of the reduced data can be determined more suitable.

[EMBODIMENT 2]

The following describes another embodiment of the present invention on reference to FIGS. 5, 10, 18 and 19. Here, for convenience of explanation, those members that have the same arrangement and functions, and that are described in the aforementioned embodiment 1 are indicated by the same reference numerals and the description thereof is omitted.

In the image processing method of the aforementioned embodiment, if the possibility of characters is strong, the magnification is varied by the nearest neighbor interpolation. However, if the nearest neighbor interpolation is used for an edge of characters, the edge is not enhanced sufficiently.

Therefore, in the image processing method of the present embodiment, the nearest neighbor interpolation is not just used for an edge of characters, a method of multiplying density data obtained by the nearest neighbor interpolation by enlargement scale of the various scaling (i.e., "to enlarge by magnification") is adopted.

An output image which was subject to the variable scaling process is shown in FIG. 18.

In other words, in order to enlarge a read picture element shown in FIG. 10 twice, when the region segmentation data is referred to and are judged to be character section, the nearest neighbor interpolation is used. Moreover, the variable scaling process is per-

formed on a section, which was judged to be a photographic section, by the interpolation of first degree. Therefore, the output image shown in FIG. 13 is obtained.

However, in the present embodiment, when the density of a picture element judged to be character section takes a value representing half tone, namely, in the case of an edge of characters, the nearest neighbor interpolation is not just used, but the magnification of the density data obtained by the nearest neighbor interpolation is enlarged by magnification and the pulse width is corrected.

A judgment can be made as to whether or not the density of the picture element takes a value representing half tone by whether or not the density of the picture element has a value which falls within a range of 0 to 255.

More specifically, as shown in FIG. 18, pulse widths (density of picture element) are corrected on sections of edges a and a' and edges b and b' of characters. First, a density, which was obtained by multiplying the density of the picture element obtained by the nearest neighbor interpolation by the magnification, is given to one picture element on each side of the density slope where the density is high in two picture elements of the edges, namely, the picture element on the edge a' side and the picture element on the edge b side.

Meanwhile, the density 0 is given to one picture element on each side of the density slope where the density is low in two picture elements of the edges, namely, the picture element on the edge a side and the picture element on the edge b' side.

According to this correction of the pulse width (density of a picture element), the density of the picture elements on the inside in the two picture elements of the edges of characters is multiplied by the magnification, and the density of the picture elements on the outside is changed to 0. As a result, the edge of characters is enhanced more than the use of the nearest neighbor interpolation, and thus a clear image can be obtained.

The nearest neighbor interpolation is used in principle for the section, which was judged to be the character section by the region segmentation section 3, namely, the left section of the drawing (the section marked with "judged to be character section"), and the pulse widths on the edges of characters are corrected. As a result, the edges are enhanced more than the case of FIG. 13, and thus a clear image can be obtained.

In addition, in the section, which was judged to be a photographic section by the region segmentation section 3, namely, the right half of the drawing (the section marked with "judged to be photographic section"), the tone production becomes satisfactory by adopting the interpolation of first degree, and a pseudo-contour is hardly caused.

The pulse width modulator 16 outputs images for each picture element based upon the special data 4c including the picture element density slope data, and the scaling-processed γ corrected image data 5a. As mentioned in embodiment 1, when the special data 4c of 2 bits per picture element take 00B representing being centered, the pulse width modulator 16 generates continuous ON signals so as to be centered on the picture element.

More specifically, as shown in FIG. 5(c), the input image data is 80H, i.e., has density of 128/256 and the input picture element density slope data are 00B representing being centered, one-fourth (64/256) picture element from the front is turned off, and the next half of picture element is turned on, and the rest one-fourth of the picture element is turned off. In such a manner, the pulse width modulator 16 changes an ON data position of one picture element by adjusting an output of a laser.

Therefore, the image data which were subject to the character edge process are represented by FIG. 19(a), for example. The small rectangles 8 represent respectively one output picture element, and numerical values of the rectangles 8 represent density of each picture element (256 tone).

When the input picture element density slope data are 00B representing being centered, an image which is outputted based upon this image data is represented by FIG. 19(b). Namely, when the input picture element density slope data are the 00B representing being centered, a gap of an OFF signal is generated on an edge section. This is called as a ghost contour.

Therefore, in the present embodiment, when the position of the ON signal in one picture element is centered, in FIG. 19(b), the output control section 6 changes the position of the ON signal in one picture element by modulating the pulse width of this picture element so as to prevent a ghost contour.

In other words, picture elements on second through fourth rectangles on the leftmost file from the top 80H (i.e., 128) as shown in FIG. 19(a), and the second file from the left is FFH (i.e., 255). As a result, the density slope on the picture elements is such that the density on the left side is low and the density on the right side is high.

In addition, in FIG. 19(b), picture elements on the second through fourth rectangles on the rightmost file from the top are 80H as shown in FIG. 19(a), the second file from the right is FFH. As a result, density slope on these picture element is such that the density on the left side is high and the density on the right side is low.

Therefore, according to this information, when the density slope of target picture elements is such that the density on the left side is low and the density on the right side is high, a picture element output is changed to data (10B) representing being shifted to the right, and when the density slope of target picture elements is such that the density on the left side is high and the density on the right side is low, a picture element output is changed to data (01B) representing being shifted to the left.

In this manner, the output control section 6 changes the position of the ON signal in one picture elements by modulating the pulse width. As a result, as shown in FIG. 19(c), a gap of the OFF signal is not produced on

an edge section of characters, thereby making it possible to prevent the ghost contour.

In accordance with the image processing method of the present embodiment, picture element density slope data S of adjacent picture elements are given to each picture element of an image. Meanwhile, in the case where the region segmentation data X_p of the picture element P is 0 (X_p=0), the density D_a of the picture element A which is the closest to the picture element P is half tone density and the picture element density slope data S_p of the picture element P are positive, namely, data which represent that $D_a < D_p < D_b$, the density D_p of the picture element P is converted into the value obtained by multiplying the half tone density and magnification together, and the density D_a of the picture element A is set to 0. Moreover, when the density D_a of the picture element A are half tone density and the picture element density slope data S_p of the picture element P are negative, namely, data which represent that $D_a > D_p > D_b$, the density D_a of the picture element A is converted into a value obtained by multiplying the half tone density and magnification together, and the density D_p of the picture element P is set to 0.

In other words, when the read image is character data and the picture elements on a reading position is an edge of the characters, the picture elements mostly have half tone density. Thereafter, when the variable scaling process is performed according to the equation (1), the picture elements having the half tone density continue, and thus the edge becomes unclear.

However, in accordance with the above method, when the density D_a of the picture element A which is the closest to the picture element P is half tone density and the picture element density slope data S_p of the picture element P is positive, namely, $D_a < D_p < D_b$, the density D_p of the picture element P is converted into a value obtained by multiplying the half tone density and magnification together, and the density D_a of the picture element A is set to 0. Meanwhile, when the density D_a of the picture element A is half tone density and the picture element density slope data S_p of the picture element P is negative, namely, $D_a > D_p > D_b$, the density D_a of the picture element A is converted into a value obtained by multiplying the half tone density and magnification together, and the density D_p of the picture element P is set to 0.

Therefore, when a pulse width of picture elements for outputting a laser is modulated according to magnification, the density of edges of characters is further enhanced, and a clearer image can be obtained compared with the case where the nearest neighbor interpolation is just used.

In addition, in the image processing method of the present embodiment, a laser is outputted to a portion of picture elements where the density is high based upon the picture element density slope data on the picture elements to which a value obtained by multiplying the half tone density and magnification together was given.

Namely, in the case where the read image is character data and the picture element on the reading position is the edge of the image, when, for example, 8 bits/picture element is processed and the picture element has the half tone density, the density of the picture element is 128, i.e., 80H. Therefore, an image output apparatus which modulates the pulse width on one picture element so as to output a half-tone image, image data of 80H generates a half dot of one picture element in a center position of the picture elements. Then, in the case where the picture element where the half dot is generated in its center position is enlarged, a white picture element of a half dot appears between the above picture element and the adjacent picture element, and the appearance of this white picture element is repeated for one picture element. Therefore, there arises a problem that a ghost contour occurs.

However, in accordance with the above method, a laser is outputted to a portion of picture elements where the density is high, based upon the picture element density slope data on the picture elements to which a value obtained by multiplying the half tone density and magnification together was given.

Therefore, when the edge of the character data is subject to the variable scaling process through the image processing method in claim 5, a ghost contour is prevented from being caused on the left or right of one picture element on the edge of the character data.

[EMBODIMENT 3]

The following describes still another embodiment of the present invention in reference to FIGS. 12 and 24. Here, for convenience of explanation, those members that have the same arrangement and functions, and that are described in the aforementioned embodiments 1 and 2 are indicated by the same reference numerals and the description thereof is omitted.

As shown in FIG. 20, the digital copying machine of the present embodiment is arranged so that besides the arrangement shown in FIG. 1, a second image processing section 15 is provided between the variable scaling section 4 and the output control section 6. A scaling-processed image can be transmitted from the second image processing section 15 to an asynchronizer 10 such as a facsimile and a personal computer.

In other words, as described in embodiment 1, in the digital copying machine, the image input section 1 reads a document image from a scanner, not shown, and converts the read image into the digital input image data 1a. Next, the shading correcting/automatic exposing section 2 performs the shading correction and the automatic exposure for the input image data 1a.

In addition, the region segmentation section 3 refers to density, etc. of picture elements in the vicinity of a target picture element of image data 2a which were subject to the shading correction and the automatic exposure so as to detect possibilities of characters, photographs and mesh dots of the target picture element. Then, the region segmentation section 3 outputs image

data 3a and region segmentation data 3b.

The variable scaling section 4 performs scaling process on the inputted image data 3a and the region segmentation data 3b, and refers to picture elements in the vicinity of the target picture element so as to determine density slope of the target picture element. Then, the variable scaling section 4 outputs scaling-processed image data 4a, scaling-processed region segmentation data 4b and special data 4c.

At the time of the above variable scaling process, the equation (1) is used for the image data 3a, and the nearest neighbor interpolation is used for the region segmentation data 3b. Moreover, the special data 4c are composed of directing data, which show the front and rear of the line of the region segmentation data 3b and the end of the image data, and picture element density slope data S with respect to a picture element which is currently subject to the process. Further, when the region segmentation data 3b are other than data which represent strong possibility of characters, the picture element density slope data S are outputted as "no slope".

These outputs are outputted to the second image processing section 15. Then, they are transmitted to the asynchronizer 10 such as a facsimile and a personal computer, which is additionally provided, by a method, mentioned later.

On the contrary, an image which is scaled by another digital copying machine is received by and inputted to the second image processing section 15 via the asynchronizer 10 such as facsimile.

The scaling-processed image data 4a inputted into the second image processing section 15, the scaling-processed region segmentation data 4b and the special data 4c or the received and inputted variable magnification processed image are outputted as scaling-processed γ corrected image data 15a, scaling-processed region segmentation data 15b and special data 15c. Then, image output is controlled by the output control section 6, and a laser is outputted based upon a signal of inputted output image data 6a by the image output section 7.

The following described input and output of data from the variable scaling section 4 to the second image processing section 15.

As shown in FIG. 21, the image data 3a stored in a line memory 17a and the region segmentation data 3b stored in a line memory 17b are inputted into the variable magnification processing section 4.

In addition, the output data from the variable magnification processing section 4 are the special data 4c stored in a line memory 18a, the magnification varied image data 4a stored in a line memory 18b and the magnification-varied region segmentation data 4b stored in a line memory 18c.

When the scaling-processed image data 4a and the scaling-processed region segmentation data 4b are outputted, directing data, which represent starting of data, the rear of each line and end of the image data, are added to the special data 4c. The information which represents the starting of data, the rear of each line and the end of the image data, is given at the same time when the input image data are inputted from the image input section 1.

More specifically, in order to represent the starting of the scaling-processed image data 4a and the scaling-processed region segmentation data 4b as shown in FIGS. 22(a) and 22(b), start directing data 20 are outputted as the directing data, which represent the starting of data, on output special data as indicated by a circle in FIG. 22(b). Moreover, in order to represent the rears of the lines of the scaling-processed image data 4a and the scaling-processed region segmentation data 4b as shown in FIGS. 23(a) and 23(b), rear directing data 21 are outputted as directing data, which represent the rears of the lines, on the output special data as indicated by a circle in FIG. 23(b). Further, in order to represent the end of the whole image data of the magnification varied image data 4a and the scaling-processed region segmentation data 4b as shown in FIGS. 24(a) and 24(b), image data end directing data 22 are outputted as directing data, which represent the end of the whole image data, on the output special data as indicated by a circle in FIG. 24(b).

In such a manner, directing data 20, 21 and 22, which respectively represent the front and rear of a line and the end of image data are given to the special data 4c, and the scaling-processed image data 4a and the scaling-processed region segmentation data 4b are combined so as to be outputted. As a result, a line counter or the like is not required even in the second image processing section 15, and output data can be generated by a simple arrangement of hardware so as to be transmitted to the asynchronizer 10.

As mentioned above, the image processing method of the present embodiment reads an image, divides the read image into blocks composed of a plurality of picture elements and interpolate each picture element so as to variably scale the image. In accordance with this image processing method, possibilities of characters, photographs and mesh dots of each picture element of the image are detected by the region segmentation section 3, and the scaling-processed image data 4a as interpolated picture element data of each picture element are computed by the variable scaling section 4 based upon the detected result so as to scale the image. Meanwhile, at the time of the computation of the scaling-processed image data 4a per picture element, the region segmentation data 3b detected by the region segmentation section 3 are subject to the variable scaling process based upon the result detected by the region segmentation section 3 so as to be outputted as the scaling-processed region segmentation data 4b together with the scaling-processed image data 4a.

In the case where the scaling-processed image data 4a is desired to be outputted to the asynchronizer 10 such as a facsimile and a personal computer, for example, even if the region segmentation data 3b are

not subject to the variable scaling process, a number of picture elements does not agree with the scaling-processed image data 4a. Therefore, there arises a problem that the region segmentation data 3b cannot be used.

However, in the above method, also the region segmentation data 3b detected by the region segmentation section 3 are subject to the variable scaling process based upon the result detected by the region segmentation section 3 so as to be outputted as the scaling-processed region segmentation data 4b together with the scaling-processed image data 4a.

Therefore, since a number of picture elements of magnification varied image data agrees with that of region segmentation data, even if these data are outputted to an external asynchronous image input/output device such as a facsimile and a personal computer, region segmentation data can be used.

In addition, since the possibilities of characters, photographs and mesh dots are given also to the scaling-processed region segmentation data 4b, they are combined together so that the scaling-processed image can be outputted to the asynchronizer 10.

In addition, in the case where the scaling-processed image data 4a and the scaling-processed region segmentation data 4b are simultaneously outputted, the image processing method of the present embodiment simultaneously outputs the direction data 20, 21 and 22, which represent the front and rear of each line of plural picture elements on output data, and the end of image data.

In other words, in the case where the scaling-processed image data 4a are outputted to the asynchronizer 10 such as a facsimile and a personal computer, when the directing data, which represent the front and rear of the lines and the end of the image data, do not exist in the scaling-processed region segmentation data 4b, a number of picture elements for one line and a total number of lines should be transmitted to an external asynchronizer 10. Furthermore, even if the above numbers are transmitted to the synchronizer 10, a line counter should be always provided.

However, in accordance with the above method, since the directing data 20, 21 and 22, which represent the front and rear of each line of plural picture elements on the output data and the end of the image data, are simultaneously outputted, a number of picture elements of one line and a total number of lines do not have to be transmitted to an external asynchronizer 10, thereby making it possible to avoid installation of the line counter.

In the present embodiment, the nearest neighbor interpolation is used for the variable scaling process of the region segmentation data 3b, but the method is not limited to this, and thus the scaling process can be performed based upon the region segmentation data 3b like scaling of image data.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An image processing method for scaling an image, comprising the steps of:

   dividing an image into blocks composed of a plurality of picture elements so as to detect region segmentation data, which represent possibilities of characters, photographs and mesh dots in a block of a target picture element, by region segmentation means per target picture element; and
   computing density of the target picture element on the output image by using computing means according to an equation into which density of a plurality of adjacent picture elements in the vicinity of the target picture element are inputted,

   wherein in said computing step, a weight of the density of each adjacent picture element in the equation is adjusted according to the region segmentation data of the target picture element.

2. The image processing method according to claim 1, wherein in said computing step, the weight of the density of each adjacent picture element in the equation is adjusted so as to fall within a range of a weight obtained by the nearest neighbor interpolation to weights obtained by the interpolations of first through third degrees.

3. The image processing method according to claim 1, wherein in said computing step, as the possibility of characters represented by the region segmentation data is stronger, a weight of density of an adjacent picture elements which is the closest to the target picture element in the equation is set larger, and as the possibilities of photographs and mesh dots represented in the region segmentation data are stronger, the weight is set smaller.

4. The image processing method according to claim 1, wherein:

   in said detecting step, the region segmentation data are set so as to take a value X which falls within the range of 0 to N-1 (N is an integral number not less than 2) and so that as the possibility of characters is stronger, the region segmentation data takes a smaller value and as the possibilities of photographs and mesh dots are stronger, the region segmentation data takes a larger value,

in said computing step, density D_p of a picture element P which is a target picture element whose density should be determined, is computed according to the following equation:

$$D_p = (1-K) \times D_a + K \times D_b \quad (1)$$

(However,
$K = (X_p/(N-1)) \times (PA/(PA+PB)))$
where X_p is region segmentation data of the picture element P, D_a is density of a picture element A which is the closest to the picture element P, D_b is density of a picture element B which is the second closest to the picture element P, PA is a distance between the picture element P and the picture element A, and PB is a distance between the picture element P and the picture element B.

5. The image processing method according to claim 4, further comprising the steps of:

obtaining picture element density slope data which represent density slope of the picture element P with respect to picture elements which are adjacent to the picture element P after said computing step; and
on the picture element P whose region segmentation data X_p is 0 and whose density D_p is half-tone density, and on the picture element A which is the closest to the picture element P, when the picture element density slope data are data representing a relationship $D_a < D_p < D_b$, converting the density D_p into a value obtained by multiplying the half-tone density and magnification of the various scaling together and setting the density D_a to 0, whereas when the picture element density slope data are data representing a relationship $D_b < D_p < D_a$, converting the density D_a into a value obtained by multiplying the half-tone density and magnification together and setting the density D_p to 0.

6. The image processing method according to claim 5, further comprising:

the step of outputting a laser according to density data with respect to the picture element P after said converting step,
wherein in said laser outputting step, a laser is outputted to the picture element P, to which the value obtained by multiplying the half-tone density and the magnification together is given, in a position which is shifted to a side of the picture element where the density is higher based upon the picture element density slope data of the picture element P.

7. The image processing method according to claim 1, wherein in said computing step, when the data of each target picture element is computed by said computing means, magnification of the region segmentation data detected by said region segmentation means is scaled so as to be outputted together with the scaled image data.

8. The image processing method according to claim 7, wherein the variable magnification process for the region segmentation data in said computing step is performed by using the nearest neighbor interpolation.

9. The image processing method according to claim 7, wherein the variable magnification process for the region segmentation data in said computing step is performed based upon the result detected by said region segmentation means.

10. The image processing method according to claim 7, further comprising:

the step of simultaneously outputting the scaled image data and the scaled region segmentation data after the computing step,
wherein in said outputting step, directing data, which represent a front and a rear of each line of plural picture elements on the output data and end of the image data, together with the scaled image data and the scaled region segmentation data.

11. The image processing method according to claim 1, further comprising:

the step of obtaining picture element density slope data which represent density slope of the target picture element with respect to picture elements which are adjacent to the target picture element after said computing step; and
the step of outputting a laser according to the density data of each picture element,
wherein in said laser outputting step, a laser is outputted to the target picture element, to which the value obtained by multiplying the half-tone density and the magnification of the various scaling together is given, in a position which is shifted to a side of the picture element where the density is higher based upon the picture element density slope data of the target picture element.

12. The image processing method according to claim 1, further comprising the step of reading a document image and converting the read image into image data so as to input the image data into said region segmentation means before said detecting step.

13. The image processing method according to claim 1, wherein:

said image processing method is a method of enlarging an image composed of a plurality of picture elements by inserting interpolated picture elements respectively between the picture elements,
the target picture element of which the density computed in said computing step is the interpolated picture element.

14. The image processing method according to claim 13, further comprising the step of reading a document image and converting the read image into image data so as to input the image data into said region segmentation means before said detecting step.

15. An image processing apparatus for scaling inputted image so as to output the magnification varied image, comprising:

region segmentation means for dividing the input image into blocks composed of a plurality of picture elements and detecting region segmentation data, which represent possibilities of characters, photographs and mesh dots of a block of a target picture element per target picture element; and
computing means for computing density of the target picture element on the output image by using an equation in which density of a plurality of adjacent picture elements in the vicinity of the target picture element is inputted,
wherein said computing means adjusts a weight of the density of each adjacent picture element in the equation according to the region segmentation data of the target picture element.

FIG. 1

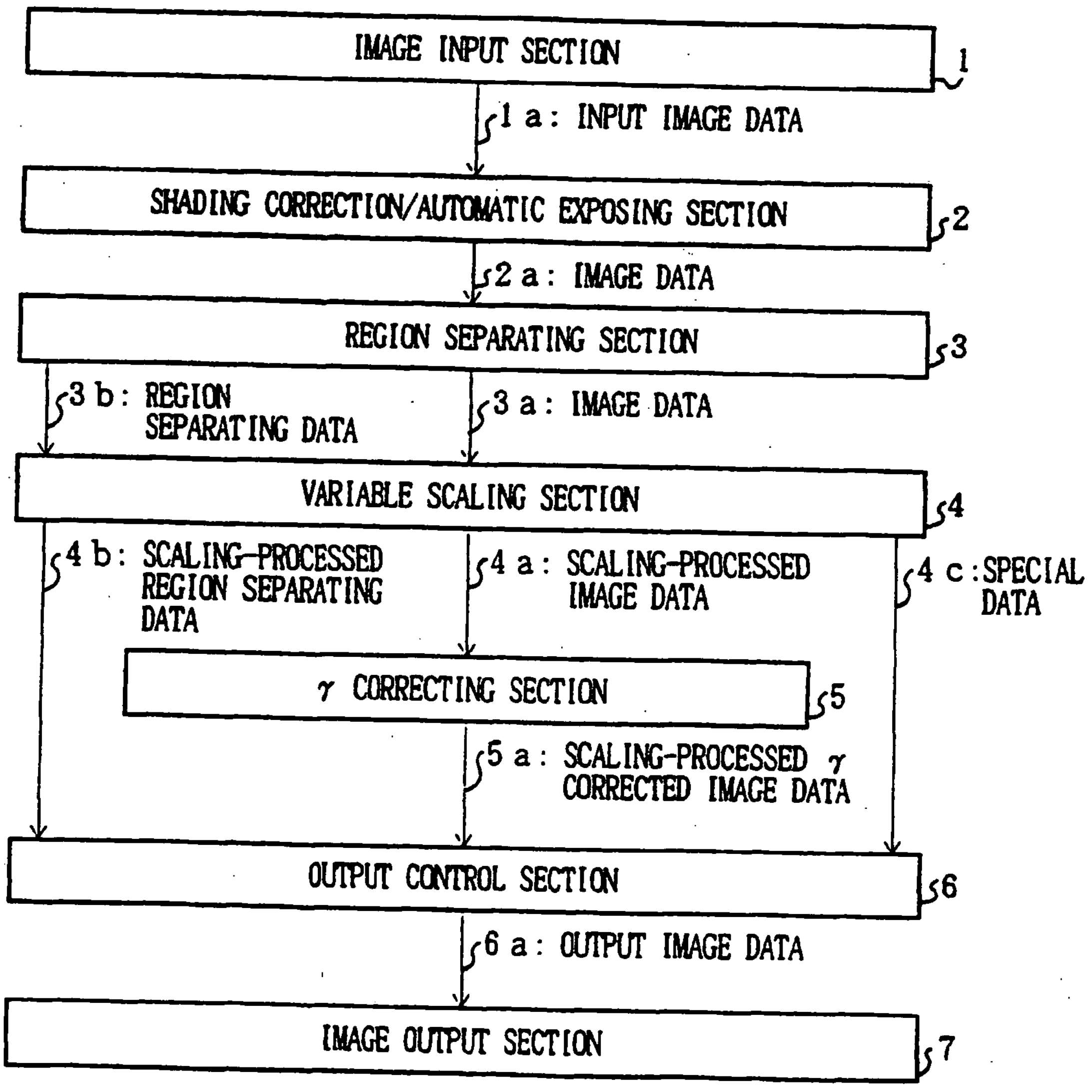


IMAGE INPUT SECTION
1
1 a: INPUT IMAGE DATA
SHADING CORRECTION/AUTOMATIC EXPOSING SECTION
2
2 a: IMAGE DATA
REGION SEPARATING SECTION
3
3 b: REGION SEPARATING DATA
3 a: IMAGE DATA
VARIABLE SCALING SECTION
4
4 b: SCALING-PROCESSED REGION SEPARATING DATA
4 a: SCALING-PROCESSED IMAGE DATA
4 c: SPECIAL DATA
γ CORRECTING SECTION
5
5 a: SCALING-PROCESSED γ CORRECTED IMAGE DATA
OUTPUT CONTROL SECTION
6
6 a: OUTPUT IMAGE DATA
IMAGE OUTPUT SECTION
7

FIG. 2

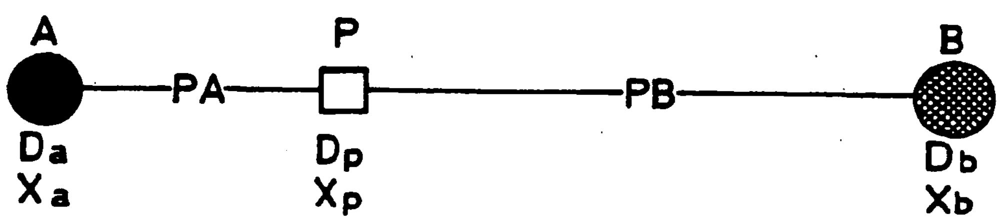


FIG. 3

Xa, Xb

Da, Db

4

WHEN
OUTPUT PICTURE ELEMENT: P, NEAREST NEIGHBOR PICTURE ELEMENT: A, SECOND NEIGHBOR PICTURE ELEMENT: B
PA DISTANCE : PA, PB DISTANCE: PB
REGION SEPARATING DATA: Xp, Xa, Xb
PICTURE ELEMENT DENSITY: Dp, Da, Db
PICTURE ELEMENT DENSITY SLOPE DATA: Sp,

$$Xp = Xa$$

$$Dp = \{1 - \frac{Xp \cdot PA}{(N-1) \cdot (PA+PB)}\} \cdot Da + \frac{Xp \cdot PA}{(N-1) \cdot (PA+PB)} \cdot Db$$

Sp = 01B: TO LEFT ($Xp = 0$: STRONG POSSIBILITY OF CHARACTER , $Da < Dp < Db$)

10B: TO RIGHT ($Xp = 0$: STRONG POSSIBILITY OF CHARACTER , $Da > Dp > Db$)

00B: TO CENTER ($Xp = 0$: STRONG POSSIBILITY OF CHARACTER , OTHER THAN THE ABOVE)

00B: TO CENTER ($Xp \neq 0$: STRONG POSSIBILITY OF PHOTOGRAPH)

Xp

Dp

Sp
CONTROL BIT

F I G. 4

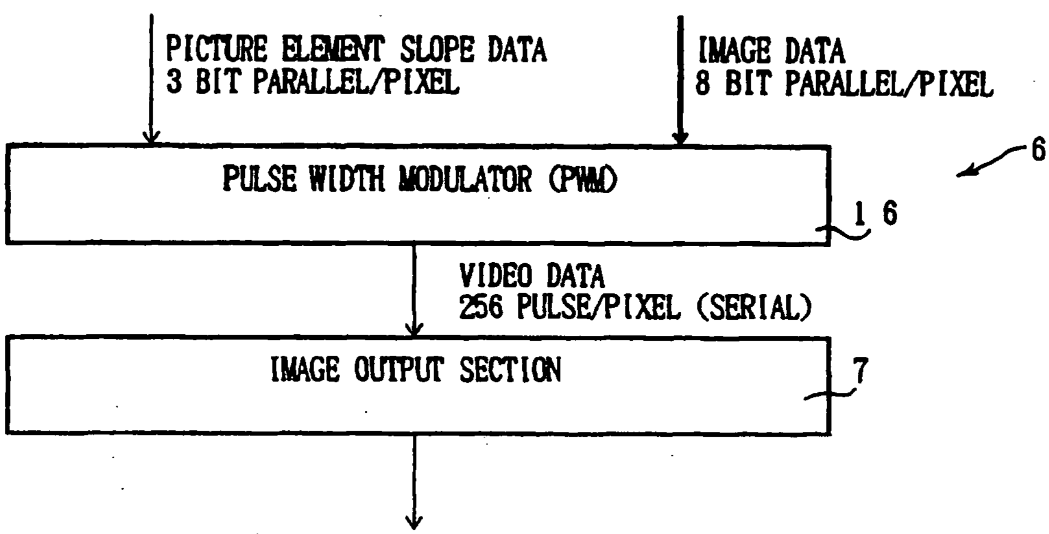

PICTURE ELEMENT SLOPE DATA
3 BIT PARALLEL/PIXEL
IMAGE DATA
8 BIT PARALLEL/PIXEL
6
PULSE WIDTH MODULATOR (PWM)
16
VIDEO DATA
256 PULSE/PIXEL (SERIAL)
IMAGE OUTPUT SECTION
7

FIG.5(a)

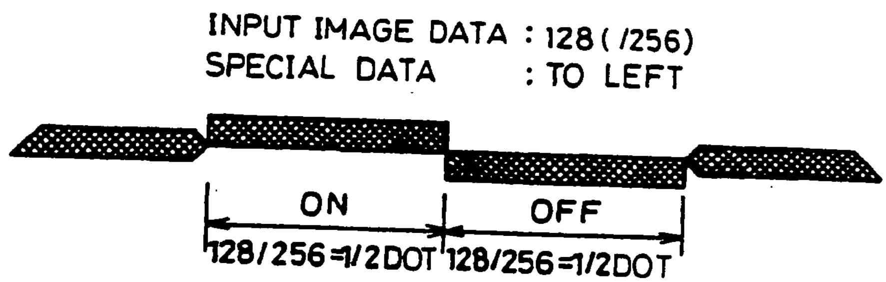


FIG.5(b)

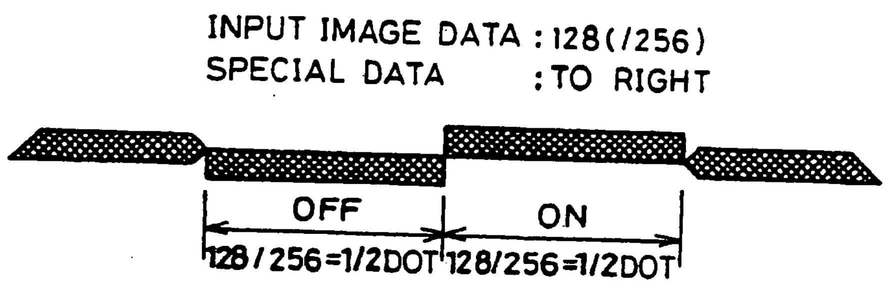


FIG.5(c)

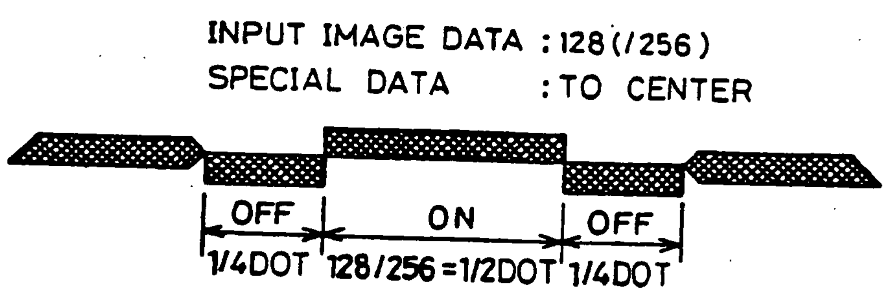


FIG.6

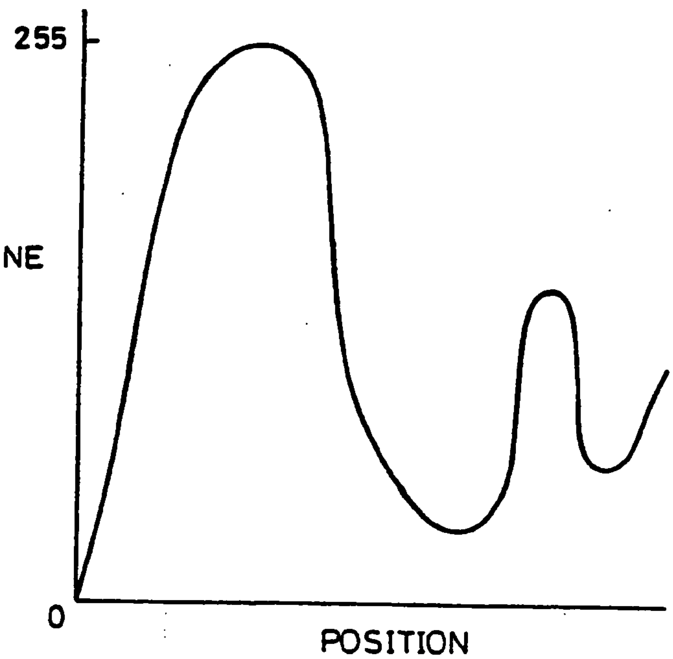
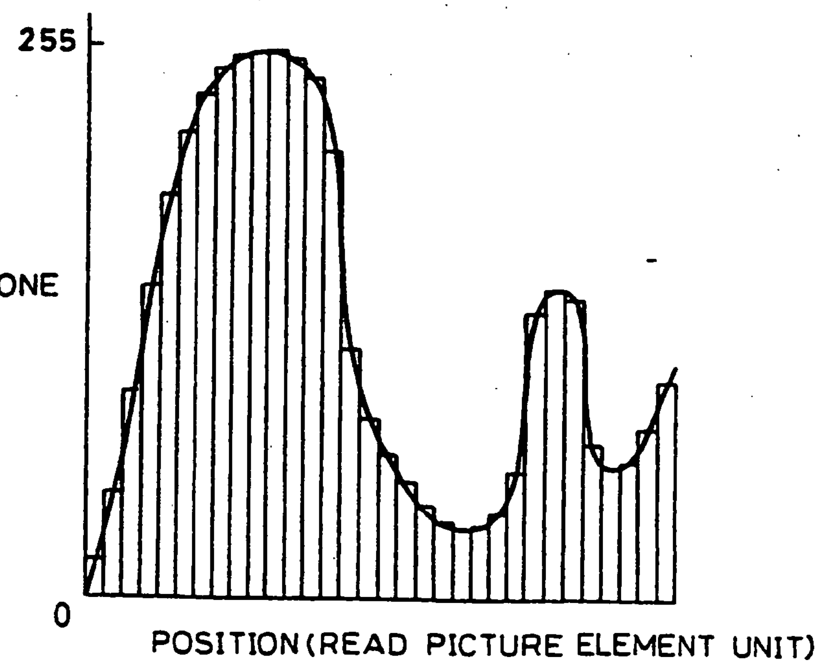

255
TONE
0
POSITION

FIG.7


255
TONE
0
POSITION(READ PICTURE ELEMENT UNIT)

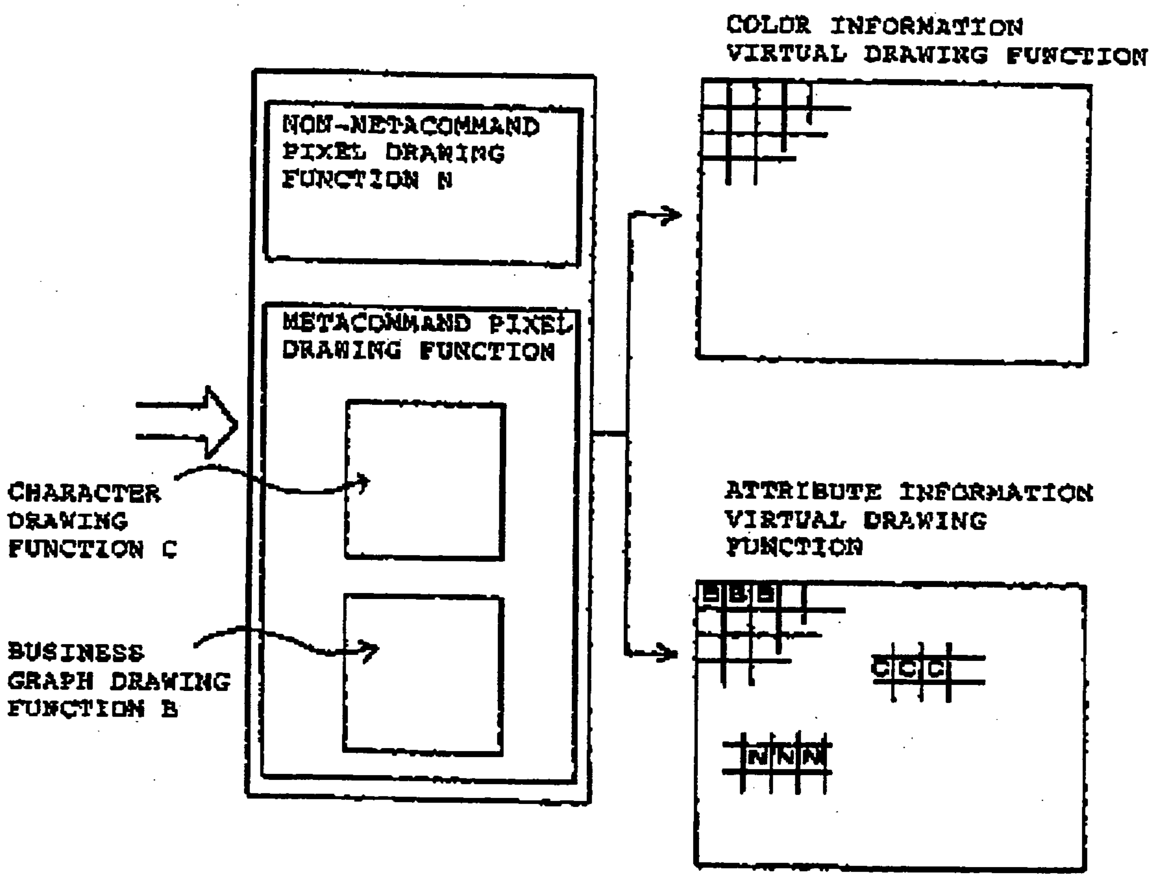

COLOR INFORMATION
VIRTUAL DRAWING FUNCTION
NON-METACOMMAND
PIXEL DRAWING
FUNCTION N
METACOMMAND PIXEL
DRAWING FUNCTION
CHARACTER
DRAWING
FUNCTION C
BUSINESS
GRAPH DRAWING
FUNCTION B
ATTRIBUTE INFORMATION
VIRTUAL DRAWING
FUNCTION
B B B
C C C
N N N

Fig. 28

Fig. 29A

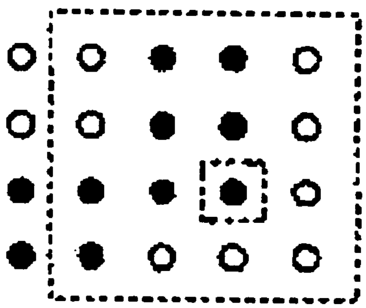


Fig. 29B

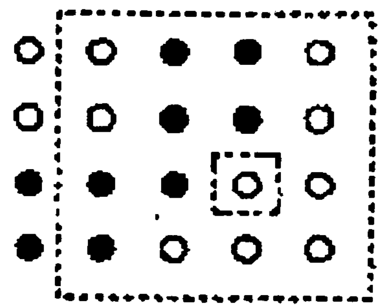


Fig. 29C

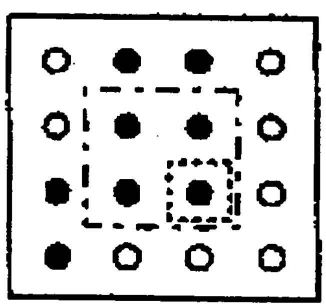
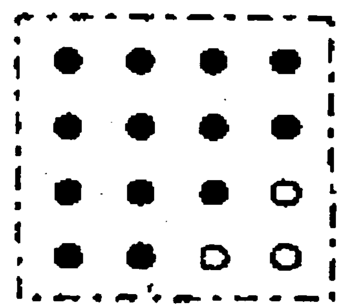


Fig. 29D



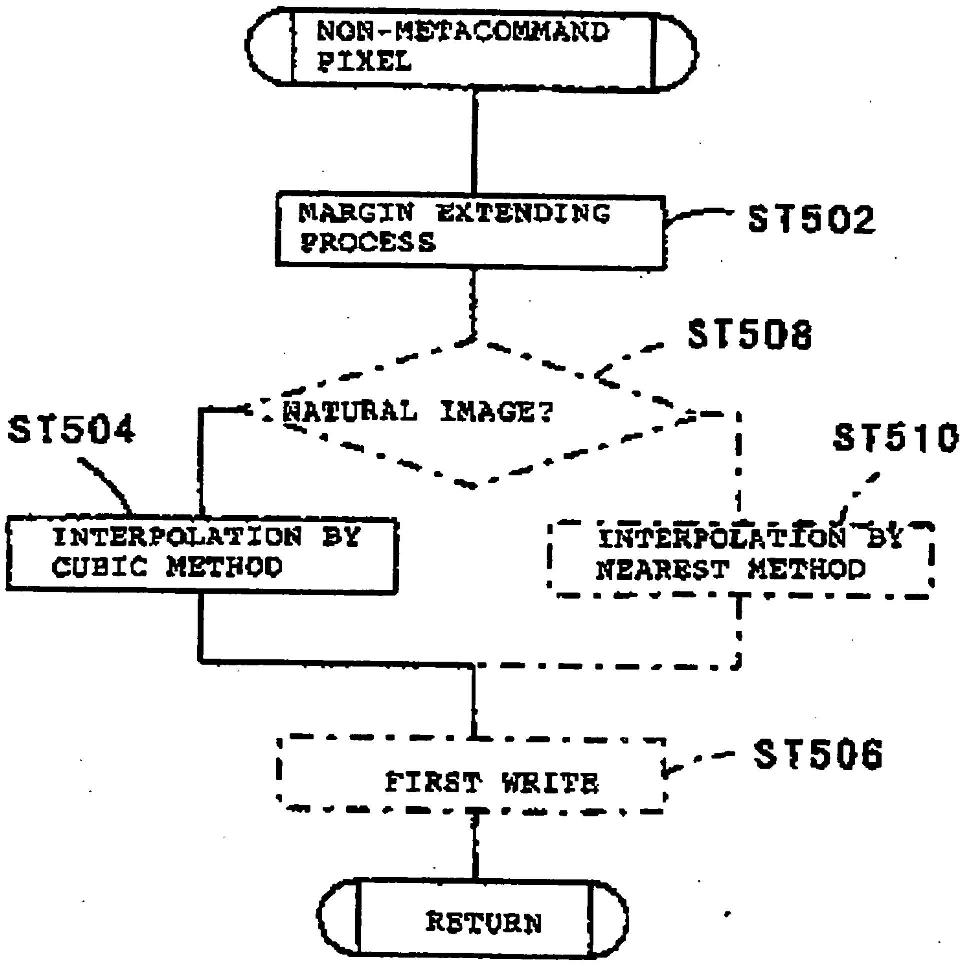

NON-METACOMMAND PIXEL
MARGIN EXTENDING PROCESS
ST502
ST508
NATURAL IMAGE?
ST504
ST510
INTERPOLATION BY CUBIC METHOD
INTERPOLATION BY NEAREST METHOD
FIRST WRITE
ST506
RETURN

Fig. 30

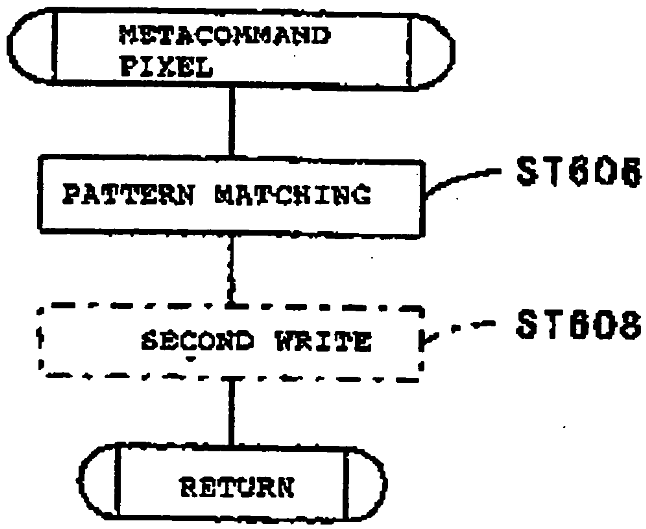

METACOMMAND
PIXEL
PATTERN MATCHING
ST606
SECOND WRITE
ST608
RETURN

Fig. 31

Fig. 32A

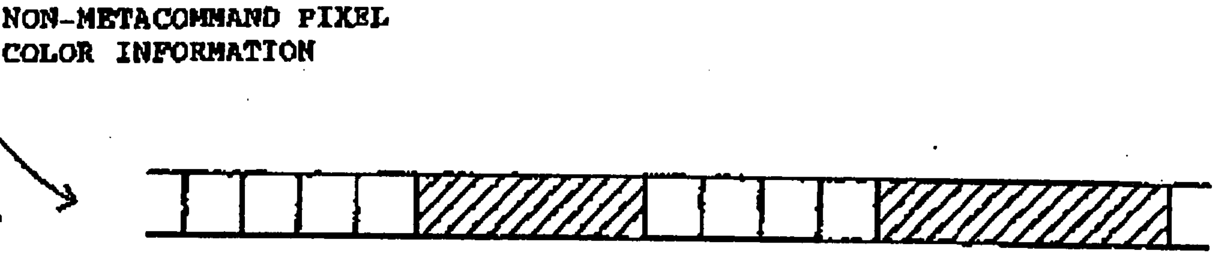


Fig. 32B

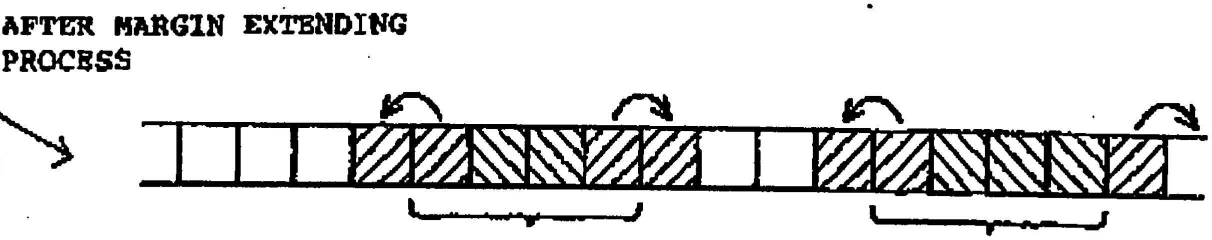
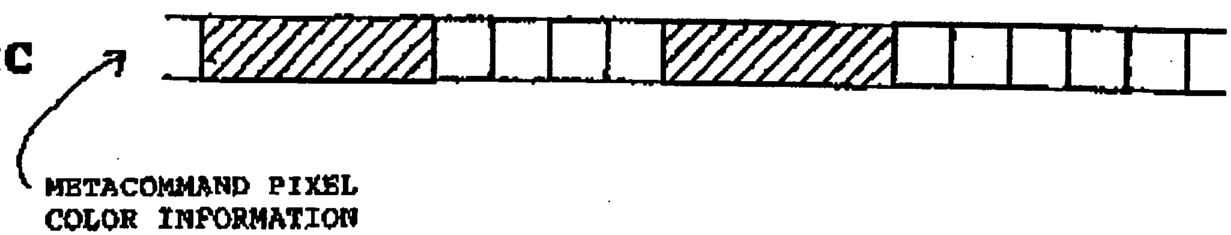
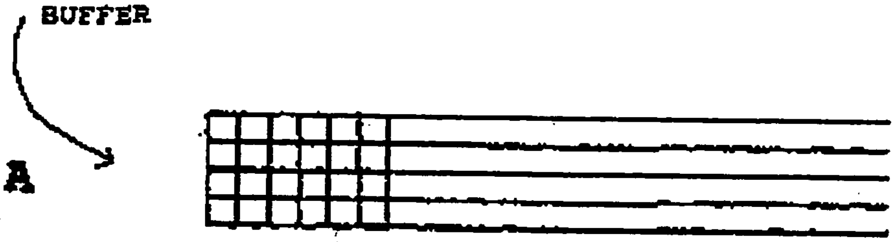


Fig. 32C



NON-METACOMMAND PIXEL
COLOR INFORMATION INTERPOLATING PROCESS
BUFFER

Fig. 33A



METACOMMAND PIXEL
COLOR INFORMATION INTERPOLATING PROCESS
BUFFER

Fig. 33B

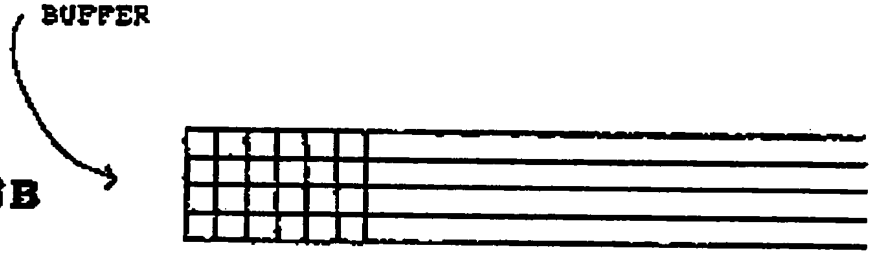


Fig. 34A

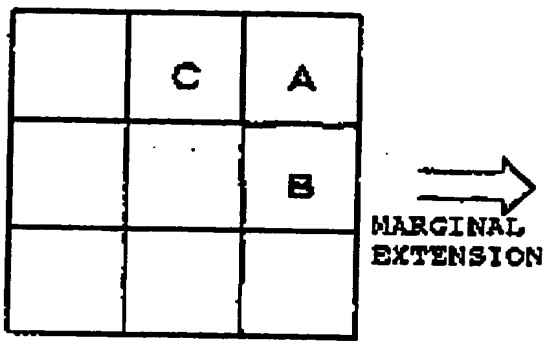
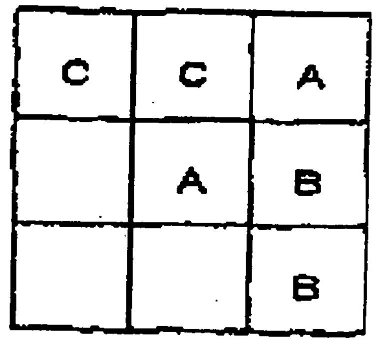


Fig. 34B



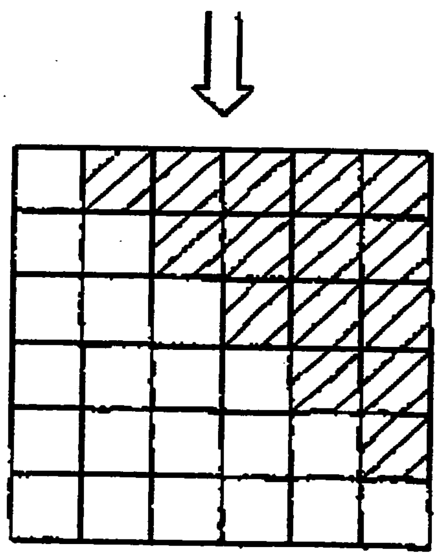


Fig. 34C

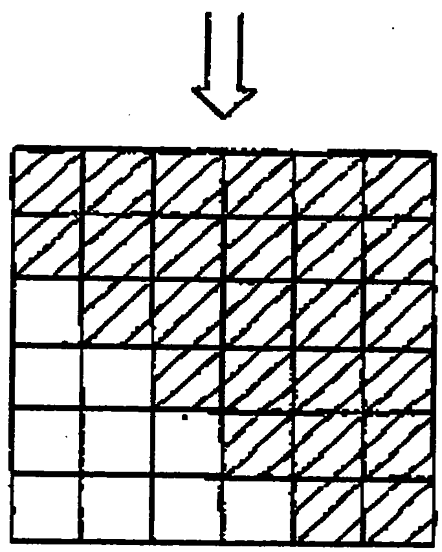


Fig. 34D